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AN ANALYSIS OF COST OVERRUNS IN THE DEVELOPMENT OF THE NAVY'S A-12 AVENGER AIRCRAFT

by

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December 1995

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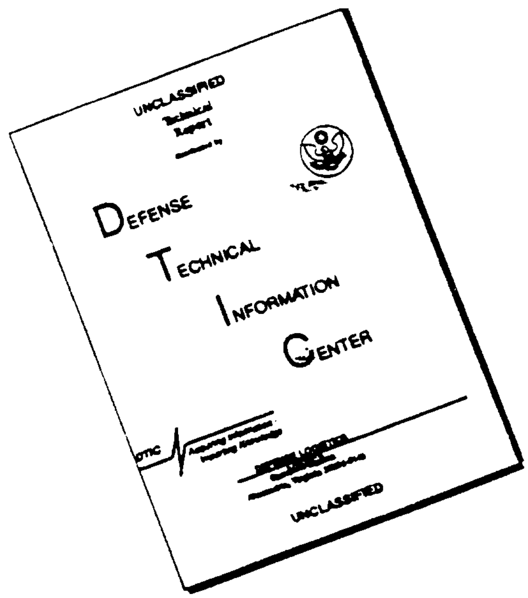

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AN ANALYSIS OF COST OVERRUNS IN THE DEVELOPMENT OF THE NAVY'S A-12 AVENGER AIRCRAFT

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ABSTRACT

This thesis examines the termination of the Navy's A-12 Program. Specifically, the research sought to answer the question: Were the A-12 Program's cost overruns exceptional when compared to other major acquisitions? Prior research indicates that most major programs experience some degree of cost variance. To determine if the A-12's overruns were exceptional, the A-12 Program and 58 other contracts for developmental work are compared. The conclusion of the research is the A-12's overruns were exceptional. The cost overruns in the A-12 Program, at termination, exceeded 97 percent of other programs examined. To complete the Program may have cost between $9 and $11 billion. The required budget adjustment to complete the A-12 Program was greater than 91 percent of other programs. The research found no difference between cost variances of fixed-price contracts and cost-type contracts. The assertion that the use of a fixed-price contract contributed to the failure of the program was not proven. There was also no statistical difference between the cost overruns of aircraft programs and other types of programs. The Government's decision to terminate the A-12 Program for cost overruns is justified, based on the sample of programs examined.

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I. INTRODUCTION

A. OVERVIEW

On 7 January 1991, Secretary of Defense Richard Cheney announced the termination for default of the Full-Scale Development contract for the Navy's A-12 Avenger program. The Secretary of Defense cited cost overruns and schedule slips in his decision to cancel the A-12. The program was estimated to be $1 billion over cost and more than one year behind schedule. The Navy's internal investigation of the program, The Beach Report, cited numerous problems with the program [Ref. 2].

In the same year Congressional Oversight Committees reviewed the Air Force's C-17 acquisition program. This program, like the A-12, was a fixed-price contract for development. In November of 1991 it was estimated to be at least $1 billion over cost and one year behind schedule. While the A-12 program was terminated, the C-17 continued into production.

The Wall Street Journal called the litigation of the A-12 program the most costly case in history with legal costs alone running $30 million per year [Ref. 28, 27 July 1994]. At stake is over $3 billion in taxpayer money, including $1.35 billion in overpayment of progress payments and a contractor claim of $1.9 billion. On 9 December 1994, U.S. Claims Court Judge Robert Hodges vacated the Termination for Default and urged the Navy and the contractors to reach a settlement [Ref. 28, 12 December 1994]. The Navy has decided to pursue the case in court and the case is expected to be heard in November of 1995.

B. PURPOSE

1. Thesis Objectives

The intent of this research is to answer a straightforward question: Were the Navy's A-12 cost overruns exceptional when compared to other major acquisitions? The answer to this question is intended to be simple: yes or no. It is apparent from the history of major aircraft acquisitions that cost and schedule overruns alone do not account for the termination of programs. This research examines the cost variances within the A-12 program, in comparison with other major acquisitions. Cost overruns can be attributable to many factors such as poor cost estimation, poor management or technical difficulty. The potential for costs overrunning the ceiling price was recognized within a year of the start of Full-Scale Development (FSD). According to an analyst at the Office of the Under Secretary of Defense for Acquisition and Technology (OUSD A&T), earlier accounting for these costs may have kept the program alive. [Ref. 4]

2. Research Questions

Primary Research Question: Were the cost overruns on the A-12 contract exceptional when compared to other major aircraft acquisitions and other major defense acquisitions?

Subsidiary Research Questions:

(1) What would the A-12 FSD program have cost if it continued to completion?

(2) Was the Secretary of Defense justified in canceling the A-12 program?

(3) Are there differences in cost overruns between fixed-price contracts and cost-type contracts?

(4) Do differences exist in cost overruns of aircraft acquisitions and other major acquisitions?

(5) What is the average cost overrun of a developmental contract?

3. Expected Benefit

This research is intended to determine if cost overruns in the A-12 program justified the termination for default when compared to other major aircraft acquisition programs. The primary benefit of this study is to provide insight into the effects of cost variances. This research provides the program manager with comparison data that can provide reference points for progress.

4. Boundaries

Only contracts for developmental programs are examined. No comparison is attempted to programs in earlier or later phases, and the reader is cautioned that techniques used in this study may not be applicable to other phases of the acquisition process. While there are studies that indicate many programs experience cost and schedule variances, this study specifically examines the role of these variances in the decision to terminate the Navy's A-12 Avenger program.

The intent of this research is to examine cost overruns in the A-12 program and provide a statistically valid finding on whether the A-12 program experienced extraordinary cost overruns. The methodology uses non-linear cost estimation models and non-parametric statistics. Recognizing that some readers of this study may not be familiar with these techniques many of the details of the computations are not included in the text. Except where required for background or clarity, the detailed methodology may be found in Appendix B.

5. Limitations and Constraints

The contracts included in this research had to meet several criteria. First, the contract had to be for the Engineering and Manufacturing Development (EMD) phase, previously designated the Full-Scale Development phase. (For continuity, the current designation of Phase II of the acquisition process will be used.) Second, the program had to meet the requirements to be an Acquisition Category ID (ACAT ID) program. That is, at least $200 million in Research, Development, Test and Evaluation (RDT&E) funds, in 1980 constant dollars, had to have been committed to the program [Ref. 7]. Third, the program must have achieved a significant degree of completion. The significant degree of completion was selected to be 40 percent.

Only contracts from the Defense Acquisition Executive Summary (DAES) database were examined. Contracts for smaller programs were not examined.

The determination of estimates at completion used a non-linear cost estimation model commonly called the Rayleigh Distribution. This model has the ability to provide estimates at completion that are independent of current budgets. There are many other models that provide estimates at completion that were not examined due to time constraints. No attempt is made to provide a general model for predicting costs at completion.

The use of contractual information from the DAES database was contingent upon an agreement not to identify the contract or the contractor. Therefore, the contracts contained in Appendix A are listed by number for identification. Permission from OUSD

(A&T) is required prior to release of the database. The database used in this research was transferred to the Systems Management Department of the Naval Postgraduate School.

6. Assumptions

The approach used for this study was an examination of cost data from multiple contracts to determine if there were significant differences that would account for the termination of the A-12 based on cost variances. Cost information was obtained from the DAES database. Despite the judgmental selection of the contracts, an assumption is made that the contracts drawn from the database are representative of the population.

The use of the Rayleigh Distribution for estimating the cost at completion of the A-12 program is based on prior research that indicates this model accurately represents the expenditures of a EMD program. It is assumed, based on past research, that the A-12 program can be modeled using the Rayleigh Distribution.

The effects of inflation were considered during the research. Inflation would have no impact on the cost variance between Budgeted Cost of Work Performed (BCWP) and the Actual Cost of Work Performed (ACWP). If these two figures were inflated to a base year amount the cost variance would remain the same. The second area inflation was considered is in determining adjustments to the Contract Budget Base. An assumption is made that contractors base the Budgeted Cost of Work Scheduled (BCWS) and the Estimate At Completion (EAC) on predictions of future price escalation. This assumption was confirmed by a prior program manager for Lockheed and by a cost analyst with the Cost Analysis Improvement Group (CAIG). No adjustments are made for inflation.

C. METHODOLOGY

1. A-12 Cost Estimation

The estimates at completion for the A-12 were developed using a variant of the Rayleigh Distribution model. This model is defined in detail in Chapter II. The decision to use the Rayleigh model to estimate the completion cost is based on prior research conducted by Abernethy [Ref. 1], Elrod [Ref. 11], Lee [Ref. 18], Gallagher [Ref. 14] and Watkins [Ref. 29].

2. The Contract Budget Base

The use of cost variances alone does not provide a complete picture. A program that experiences significant cost variances will need an adjustment to its Contract Budget Base (CBB) if it is to continue. Ideally, there would be no cost variances within a program and no requirement to adjust the CBB. Both cost variances and CBB adjustments are examined in this research.

3. Data Sources

The data used for this study were drawn from 58 separate contracts for developmental work. Contract information was obtained from the OUSD (A&T). Supporting data were drawn from a variety of sources as listed in the references.

4. Hypotheses

a. Hypothesis 1: Cost overruns in the A-12 Program were no greater than the average cost overruns in the sample. This hypothesis was tested to determine if the A-12 cost variances and CBB adjustments were statistically different than other major programs.

b. Hypothesis 2: $\mu_{fp} = \mu_c$. There are no differences in the cost variances of fixed-price contracts and cost-type contracts.

c. Hypothesis 3: $\mu_{acft} = \mu_{sample}$. There are no differences between cost variances of contracts for aircraft and other contracts in the sample.

d. Hypothesis 4: $\mu_{cbbfp} = \mu_{cbbc}$. There are no differences in the adjustments to the Contract Budget Base for fixed-price contracts and the adjustments to the Contract Budget Base for cost-type contracts.

e. Hypothesis 5: $\mu_{cbbacft} = \mu_{cbbsample}$. There are no differences in the adjustments to the Contract Budget Base of aircraft programs and other programs in the sample.

Where μ_{sample} = the mean of the sample of ACAT ID contracts. μ_{acft} = the mean of aircraft contracts. μ_{fp} = the mean of fixed-price contracts, and μ_c = the mean of cost contracts. Hypotheses four and five include the subscript CBB. Hypotheses four and five tested the contract budget base adjustments from the indicated samples.

5. Procedure to Test the Hypotheses

a. Hypothesis 1 was tested using the data from the A-12 reports and the data from the sample contracts. The data were measured at completion points from 0 to

100 percent complete measured by dollars expended. The A-12 data will be compared based on percentile rankings.

b. Hypotheses 2 thru 5 were tested using non-parametric statistics. The Mann-Whitney test was chosen for its ease of use. The data do not support an assumption of normality that would allow a t-test. Alpha was set at .05.

6. Justification of Methodology

Prior research confirmed that the Rayleigh Distribution patterns the expenditures in developmental programs. Elrod [Ref. 11] tested the ability of the Rayleigh Distribution to provide estimates at completion for aircraft programs and found that the Rayleigh Distribution can be used for this purpose. Lee [Ref. 18] developed a technique using the Rayleigh model to determine budgets for developmental programs. Gallagher [Ref. 14] developed a methodology that provided probabilities of ending cost estimates for developmental programs based on the Rayleigh Distribution.

The cost data from the A-12 program were used to determine a percentile value based on the distribution that best patterns the data. BestFit, a commercial statistical software package was used to determine the distributions based on Chi-squared values. The software evaluates the data versus 18 distributions to provide a range of possible distributions that model the data. Appendix B contains complete information on the modeling of the data.

Testing non-normal distributed data requires tests not dependent on the parameters of the distribution. A non-parametric test is required for testing hypotheses on cost variance data. Cost variances for programs patterned a left skewed distribution. The addition of more data points did not normalize the distribution. This intuitively makes sense, if one considers there is little incentive for underruns in a program.

In determining whether the cost variances of the A-12 were exceptional it is important to determine the CBB adjustments for other programs. Hypotheses four and five tested whether certain contracts or programs experienced greater adjustments to the budget than other programs.

D. LITERATURE REVIEW

A review of the available literature revealed no directly related past effort. The most widely cited source in analyzing the failure of the A-12 program is the "Beach Report" [Ref. 2].

The Beach Report examined issues that contributed to the failure of the A-12 program. Specifically, the Beach Report sought answers to three questions, "Did the Navy...have reason to anticipate substantial additional cost increase...at the time of the Major Aircraft Review? If not, why not? If so, were senior DON and DoD leaders sufficiently apprised in the course of the Review?" [Ref. 2: p. 2] The report concluded that sufficient cost performance data existed to indicate that the contract would have significant overruns and the Program Manager "...erred in judgment by failing to anticipate substantial additional cost increase beyond the ceiling of the FSD contract..." [Ref. 2: p. 29].

Previous studies have examined the affects of cost and schedule overruns on contract costs at completion. Dr. David S. Christensen, an Associate Professor of Accounting at The Air Force Institute of Technology, examined 64 contracts of various types and programs and the ability of a program to recover from cost overruns at various stages [Ref. 3]. Using a linear regression model, Christensen tested the hypothesis that contracts were unlikely to recover from cost overruns. His results indicated that programs experiencing cost overruns, at a stage of completion between 10 to 70 percent, were highly unlikely to finish within the programmed cost baseline. Furthermore, he found that the type of contract used, the Service managing the program and the type of weapon being acquired had no significant bearing on the cost overrun incurred in the program. [Ref. 3]

Christensen's work evolved from observations made by Mr. Gary Christle and Mr. Wayne Abba, senior program analysts in the OUSD (A&T). Abba and Christle examined data extracted from the DAES database on 500 contracts and concluded there is very little chance of recovering from a cost overrun once a program is more than 15% complete. "Given a contract is more than 15 percent complete, the overrun at completion will not be less than the overrun to date, and the percent overrun at completion will be greater than the percent overrun to date." [Ref. 3]

E. REVIEW OF PRIOR RESEARCH

Two master's theses from the Air Force Institute of Technology, Captain Scott R. Heise, *A Review of Cost Performance Index Stability* [Ref. 17], and Captain Brian D. Wilson, *An Analysis of Contract Cost Overruns and Their Impacts* [Ref. 30], examined cost performance data from contracts.

Captain Heise's research examined at what point the Cumulative Cost Performance Index (CPIcum) is considered to be stable. Data from the Office of the Under Secretary of Defense (Acquisition & Technology) indicate that the CPI is normally stable at the 50 percent program completion point, and the cumulative CPI does not improve between program completion points of 15 percent to 85 percent. Captain Heise's hypothesis was that the CPI is stable when a program is greater than 50 percent complete. His definition of stability was that the CPI would not vary by more than plus or minus 10 percent.

Using data extracted from the DAES database, Heise examined 155 contracts. The contracts included various acquisition phases and contract types. His conclusion was the cumulative CPI is stable at the 50 percent point and will stabilize as early as the 20 percent completion point if the program maintains a stable baseline. Additionally, Captain Heise found that the cumulative CPI tends to worsen to some degree as the program continues, but not beyond the bounds of what is considered a stable CPI. His conclusions confirm previous work by Abba and Christle, that there is very little chance of recovery from a program cost overrun between the 15 percent and 85 percent completion points. [Ref. 17]

Captain Brian D. Wilson's research investigated Christle's assertion that of 500 contracts examined since 1977, the cost overrun at completion would be higher than the cost overrun to date. Captain Wilson examined 65 contracts, all of which had experienced cost overruns. His findings confirmed the claim. He also found that the cost overruns tend to increase as the program progresses. Captain Wilson's statistical research was performed at an 85 percent confidence level. [Ref. 30]

Two master's theses from the Naval Postgraduate School were used for background information on the application of the Rayleigh Distribution to developmental programs. Abernethy [Ref. 1], investigated the applicability of the Rayleigh Distribution to programs and Elrod [Ref. 11], tested the ability of the Rayleigh Distribution to provide estimates at completion.

Abernethy's work examined completed contracts to test the ability of the Rayleigh Distribution to model expenditures. The results showed that the expenditures of most contracts were modeled by the Rayleigh Distribution, but the predictive capability of the model was insufficient for use in obtaining accurate cost at completion estimates. [Ref. 1]

Elrod tested the predictive capability of the Rayleigh Distribution using two methods to determine which method provided the best predictions of final cost. Her sample included aircraft programs that had been completed. Elrod's results showed that either of the two models could be used to predict final costs. The model used in this research approximates the Putnam model examined by Elrod. [Ref. 11]

Two unpublished research papers were relied upon to provide an understanding of the application of the Rayleigh model. The first paper, Determining a Budget Profile from a R & D Cost Estimate, by David A. Lee et. al [Ref. 18], provided verification that the Rayleigh model patterned the expenditures in a developmental program as well as a simple description of the model. This paper is available in the Defense Technical Information Center (DTIC) database.

The second paper, *Final-Cost Estimates for Research & Development Programs Conditioned on Realized Costs,* by Mark A. Gallagher and David A. Lee [Ref. 14], provided a software tool that was used to develop estimates at completion for the A-12 program and cumulative probabilities of occurrence. This paper is also available in the DTIC database, and was presented at the 1995 Military Operations Research Society Symposium.

F. SUMMARY

This Chapter presented the objectives of the research and the hypotheses to be tested. Most programs experience cost overruns. Were the cost overruns in the A-12 Program any different than other programs?

The following chapters will provide the foundation to answer the question. Chapters II and III will present the general background information on the Acquisition Process and the A-12 Program. Chapter IV contains the data from the 58 contracts drawn from the DAES database. Chapter V is the analysis of the data and the determination of where the A-12 Program was at versus other major acquisitions. Chapter VI reviews the research questions and provides the results of the tests of the hypotheses.

II. BACKGROUND

A. OVERVIEW

This chapter provides an overview of the acquisition process as it is currently structured, and a summary of the Cost/Schedule Control Systems Criteria. This chapter also introduces techniques for estimating costs at completion for an EMD program.

The intent of this chapter is to provide the reader with sufficient background in the current Defense acquisition process, and cost estimating procedures, to better understand the events leading up to the termination of the A-12. The Acquisition Process information is drawn from OMB Circular A-109, and the DoD 5000 Series.

B. THE ACQUISITION PROCESS

1. The DoD 5000 Series

The DoD 5000 series is a set of directives and instructions issued in 1991. The series consists of DoD Directive 5000.1, *Defense Acquisition* [Ref. 6]; DoD Instruction 5000.2, *Defense Acquisition Management Policies and Procedures* [Ref. 7]; and DoD Manual 5000.2-M, *Defense Acquisition Management Documents and Reports*. These replaced the 1987 versions of DoDD 5000.1 and DoDI 5000.2.

All the military departments are subject to the guidance provided in the 5000 series which provide a single acquisition system for all defense acquisition programs. The 5000 series is implemented in a phased process with five major milestones, as shown in Figure 1. [Ref. 6]

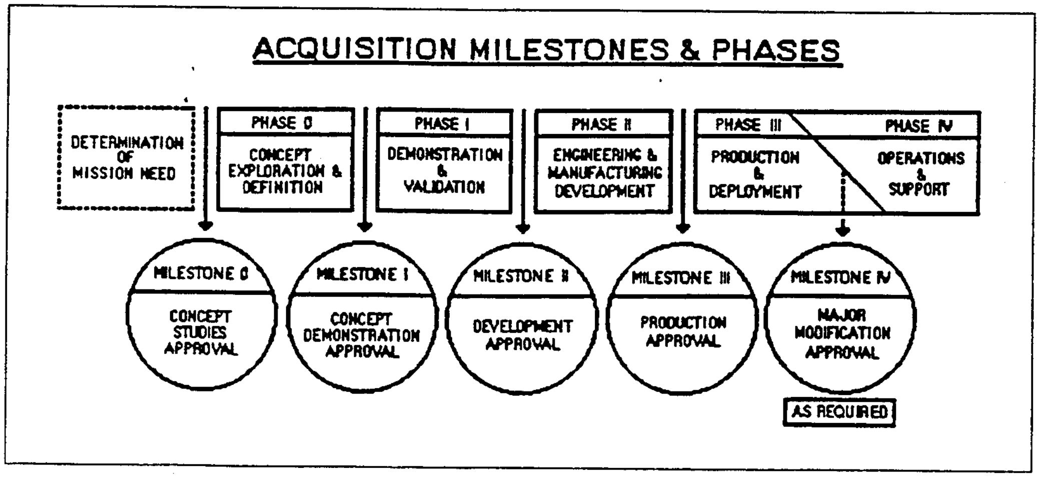

Figure 1. The Acquisition Process. [Ref. 6]

2. The Mission Need

The acquisition process begins with the identification of a deficiency in current tactics or equipment that can only be satisfied with the procurement of equipment. DoDD 5000.1 requires that a new acquisition be initiated only after "fully examining alternative ways of satisfying identified military needs." The priority in examining alternatives as specified in DoDD 5000.1 is: [Ref. 6]

1. Use or modification of an existing U.S. military system.
2. Use or modification of an existing commercially developed or Allied system that fosters a non-developmental acquisition strategy.
3. A cooperative research and development program with one or more Allied nations.
4. A new Joint-Service development program.
5. A new Service-unique development program.

The increasing sophistication of threat air defense systems degraded the capability and survivability of the A-6. The concept exploration for the A-12 began at the end of the cold war and was focused on penetrating Soviet-type air defense systems using low observable (stealth) technology. The United States Air Force (USAF) systems that incorporated stealth technology were not suitable for carrier operations without significant structural modification that would result in a new aircraft from what was originally designed for USAF missions.

The initiation of the A-12 program was based on projected USAF purchases of the aircraft in larger quantities than the Navy. Although this would not be a true "joint" program, the A-12 procurement was based on two Service's needs.

The Services submit the Mission Need Statement (MNS) to a Joint Requirements Oversight Council (JROC). The JROC determines if the need can be satisfied by other means. The JROC determines the validity of the need and forwards the MNS to the OUSD (A&T) for approval or disapproval.

The A-12 Program began in 1984 with approval of Milestone 0, approval for concept studies. The Navy contracts for Concept Exploration were awarded to the contractor teams of McDonnell Douglas/General Dynamics and Northrop/Grumman.

3. Phase 0

Phase 0 is Concept Exploration and Definition. During this phase the priority is to develop and evaluate various alternatives that could satisfy requirements. In Phase 0 initial cost estimates are conducted to determine the affordability of the proposed systems. Trade-offs are considered between cost and performance. The contract for Phase 0 in the A-12 program was issued in 1984. Phase 0 of the acquisition process begins with Milestone 0, and approval of the Mission Need Statement (MNS).

DoDI 5000.2 requires that during this phase plans must be made for competitive prototyping unless the OUSD (A&T) decides that it is not practical. Plans must also be made to allow for competitive development and production.

4. Phase I

Milestone I is the start of a new acquisition program for ACAT ID programs. ACAT ID programs are defined as programs that will expend more than $200 million in 1980 constant dollars in RDT&E or the expenditure for procurement of more than $1 billion in 1980 constant dollars. The decision authority to start a new program is the OUSD (A&T). The most promising designs from Phase 0 are carried forward into Phase I, the Demonstration and Validation Phase.

The Defense Acquisition Board (DAB) reviews the program at each milestone to determine if it meets the requirements to proceed to the next milestone. If a new program is required, the parameters for the development of the system are established and approved.

The threat is re-evaluated at Milestone I to ensure the requirements for the program still exist and have not changed. Total costs of the program are refined and affordability issues are considered. The intent of the Milestone decision is to ensure that a new program is not started when other means can satisfy the need.

The A-12 Program entered Phase I in 1986, with the award of the Demonstration and Validation contract to McDonnell Douglas/General Dynamics and Northrop/Grumman; the same teams that had conducted the concept exploration studies.

Phase I continues to define the critical design characteristics and projected capabilities of the system. Projected costs of the system are further defined as the program proceeds through the Demonstration and Validation Phase.

Risk is considered throughout the phases, but at this point the degree of risk of incorporating new technologies should be carefully considered. At the conclusion of Phase I the design to enter the Engineering and Manufacturing Development Phase is selected, and the design concepts should be relatively firm.

5. Phase II

Milestone II is the approval Milestone by the DAB to enter the Engineering and Manufacturing Development phase of a new system. Of crucial importance at the Milestone II review is the assessment that "the technologies and processes critical to success are attainable." The DAB is additionally charged with a "rigorous" assessment of the costs of the system. Prior to approval to enter EMD it should be demonstrated through testing that the system meets contract specification requirements, and operational requirements.

The focus during EMD is on the producibility of the system. The A-12 contract for EMD was awarded to the team of McDonnell Douglas and General Dynamics in January 1988, four years after initial concept studies had begun. The contractor team proposed an aggressive development schedule that would result in first flight thirty months after contract award.

6. Phase III

Phase III is the production of the actual system. Milestone III is a critical milestone in a program's lifecycle. Milestone III is the Production Approval for the system. The objectives as defined in DoD 5000.2 are to: (1) determine if the results of Phase II warrant continuation, and (2) establish a Production Baseline containing refined program cost, schedule and performance objectives. [Ref. 7] Phase III is normally divided into two unofficial sub-phases: Low Rate Initial Production (LRIP) and Full Rate Production. The purpose of LRIP is to reduce the risk of producing the system by producing it in small quantities initially, then once the producibility is verified, to begin Full Rate Production.

7. Phase IV

Phase IV usually completes the acquisition lifecycle. Phase IV is initiated by Milestone IV, Major Modification Approval. The purpose of the decision at Milestone IV is to determine if a major modification is required. In addition to major modifications, Phase IV includes the operations and support of the fielded equipment.

C. COST AND SCHEDULE CONTROL SYSTEMS CRITERIA

1. Overview

Throughout the acquisition process the cost of the proposed system is of great importance. Cost must be considered at each milestone decision. All ACAT ID programs must incorporate C/S CSC into the management of the program. Cost and schedule control systems allow program managers to track expenditures of resources in the program.

2. Requirements

DoD 5000.2 requires that the contractor submit C/S CSC information on all significant contracts that are not firm fixed-price. The definition of a significant contract for the requirement is a contract with Research, Development, Test and Evaluation (RDT&E) values of $60 million or more, and procurement contracts valued at $250 million or more, in fiscal year 1990 constant dollars. Contracts that are not determined to be significant must submit the Cost/Schedule Status Report (C/SSR). [Ref. 7]

According to DoD 5000.2, the purposes of C/S CSC requirements are to: (1) provide uniform evaluation criteria to ensure contractor cost and schedule management systems are adequate, (2) to provide an adequate basis for responsible decision making by contractor management and DoD personnel, and (3) to bring to the attention of DoD contractors, and encourage them to accept and install, management control systems and procedures that are most effective in meeting requirements and controlling contract performance. [Ref. 7]

Contractors report C/S CSC data monthly. DoD 5000.2 requires that 3 elements must be reported: (1) comparison of budgeted cost for work scheduled and the budgeted cost of work performed; (2) comparison of the budgeted cost of work performed and the actual cost of work performed; (3) variances resulting from the differences in comparisons between budgeted cost of work schedule and performed, and variances between budgeted cost of work performed and actual cost of work performed. [Ref. 7]

Of particular interest to program managers and DoD oversight personnel are the latest revised estimates (LRE) and estimates at completion (EAC) that are reported. The computation of these estimates may vary but there are four standard techniques that are explained later.

3. Purpose of C/S CSC

C/S CSC are a management tool for monitoring actual progress on a contract versus the baseline. C/S CSC begins with the formulation of a work breakdown structure (WBS) that identifies the tasks and sub-tasks that constitute the complete work package of the contract. The WBS identifies which particular tasks may be ahead or behind schedule and identifies areas where the reallocation of resources is required. The tasks and sub-tasks are provided parallel work package budgets that are traceable to the work being accomplished.

There are several methods of allocating value. One method is when work package budgets are time phased; no dollars are credited to a work package not started. Once a work package is started, 50 percent of the designated budget is credited to the package, while the remaining 50 percent is credited at completion. An alternative means of allocating earned value is to assign 100 percent of the value of the work package only when it is completed. Some distortion will be experienced in the actual progress of the contract using either of these methods.

The exact accounting system that a contractor must use to maintain C/S CSC data is not specified by the Government. A system that provides the required data does not need to be modified to meet contractual requirements.

4. C/S CSC Elements

Contractors submit the Cost Performance Report (CPR), which includes the C/S CSC data, to the program manager. For ACAT ID programs, program managers forward CPR information with the Defense Acquisition Executive Summary (DAES) Report to the OUSD (A&T). Within the OUSD (A&T) office a database is maintained of DAES CPR information. In this research, the following elements of the CPR are of importance:

a. Budgeted Cost of Work Scheduled (BCWS)

The BCWS is the dollar amount in current dollars budgeted to accomplish a specified work package in a specified time.

b. Budgeted Cost of Work Performed (BCWP)

The BCWP is the cumulative dollar amount of the sum of the completed work and the open work packages. The BCWP is the baseline item in cost reports. It represents what portion of the work has been accomplished in dollars [Ref. 30]. As used in this research, the BCWP is the cumulative dollar amount of the projected costs of the work scheduled at a specified completion point. BCWP information is drawn from the DAES database.

c. Actual Cost of Work Performed (ACWP)

ACWP is the actual costs incurred and recorded in accomplishing the work performed within a specified time period [Ref. 6]. As used in this research ACWP is the cumulative dollar amount of the actual costs for the work accomplished at a percentage completion point of the program. ACWP information is drawn from the DAES database.

d. Budget at Completion (BAC)

The BAC is the dollar amount of the contract in terms of the cumulative cost of the BCWS. It is the contractually specified dollar amount.

e. Contract Budget Base (CBB)

The CBB is the negotiated contract cost plus estimates of authorized but unpriced work. The CBB includes Management Reserve, which is money reserved for within-scope changes to the contract.

f. Estimate at Completion (EAC)

EAC is the contractor's estimate of the cumulative cost at completion of the sum of all work packages. EAC in its simplest form is the dollar amount of all costs incurred to date plus the dollar amount of all costs remaining to complete the contract. The EAC may be derived by:

$$EAC = ACWP + (BAC - BCWP) \tag{2.1}$$

g. Cost Variance (CV)

The CV is the difference between the dollar amount that was planned for the work package and the actual cost for the accomplished work package. It is determined by:

$$CV = BCWP - ACWP \tag{2.2}$$

h. Percent Cost Variance

The percent cost variance is a convenient means of comparing the magnitudes of differences between budgeted costs and actual costs. This research uses it as a comparison between different programs of varying budgets and schedules, It is a useful analysis tool and is given by:

$$\% \ CV = CV/BCWP \tag{2.3}$$

i. Cost Performance Index, Efficiency (CPI (E))

The CPI (E) measures the efficiency with which work has been accomplished by comparing the ratio of the budgeted cost of work performed to the actual cost. It is given by:

$$CPI\ (E) = BCWP/ACWP \tag{2.4}$$

j. Cost Performance Index, Performance (CPI (P))

The CPI (P) is simply the inverse of the CPI (E). This measures the actual cost of each planned dollar of work accomplished. It is given by:

$$CPI\ (P) = ACWP/BCWP \tag{2.5}$$

5. Estimates at Completion

The estimate at completion (EAC) can be derived a number of ways. Some of the more common methods involve using an efficiency index of past work performed and extrapolating this into the future to determine the final cost of the project. The Cost Performance Index (CPI) is a commonly used tool to estimate the final cost. Three methods for obtaining CPI estimates for completion costs are:

a. Cumulative CPI (CPIcum)

The EAC (CPIcum) is given by:

$$EAC\ (CPIcum) = BAC/CPI(E) \tag{2.6}$$

This EAC uses the cumulative budgeted costs to date and the cumulative actual costs to date to derive an efficiency of work index. The assumption is the efficiency index derived will remain stable into the future. Gary Christle and Wayne Abba examined over 500 contracts from the DAES database and found that the Cumulative CPI will remain stable between 15 and 85 percent complete in a program. Christle and Abba's observations were verified empirically by Heise [Ref. 17]. Heise examined a sample of 155 contracts from the DAES database and confirmed that the Cumulative CPI remains stable between 20 percent complete and 85 percent complete.

b. Weighted CPI

This method of estimating the final cost of a contract is essentially the same formula as (2.6) above. The primary difference is the use of more recent data in the CPI (E) divisor. Commonly used weightings include 3 and 6 month CPI measurements. It has been found that the Weighted CPI will tend to give a higher estimate at completion than the Cumulative CPI. Normally, a range of estimates will be given to the program manager by the cost analyst.

c. CPI/SPI

The CPI/SPI estimate at completion is given by:

$$\text{EAC (CPI/SPI)} = \text{BAC} \times [(\text{CPI(P)}/\text{SPI(E)})] \tag{2.7}$$

The CPI/SPI estimate is based on a ratio of the cost of the work performed and the scheduled time of the work performed. This approach balances the cost and schedule to determine the ending cost.

6. Cost Overruns

Cost overruns are common in weapon system development programs. A Rand Report [Ref. 10] found the average cost growth in the development phase was 25 percent, and the average cost growth in the production phase was 18 percent. The report also found that overruns varied by Service. No single cause for the cost growth could be determined. Two variables that showed a strong correlation to cost growth were program size and program maturity. The smaller the program the greater the cost variance from the baseline, and the longer the program, the greater the cost variance. Table 1 provides a summary of the Rand reports findings.

Program Type	Cost Growth	Summary	Cost Growth
Vehicles	1.77	Total RDT&E	1.25
Aircraft	1.28	Procurement	1.18
Electronics	1.24		
Munitions	1.22	Army Programs	1.35
Missiles	1.17	USAF Programs	1.20
Space Systems	1.16	Navy Programs	1.16
Helicopters	1.13		

Table 1. Cost Growth by Type of Program. [Ref. 10]

Surprisingly, the Rand report found that vehicles experience the greatest cost growth. The Rand study adjusted the budgets for inflation. The report did not test for statistical difference between either the types of programs or Service. Measuring cost variances is a relatively straightforward procedure. Estimating costs at completion is more difficult. The next section introduces a method that can provide estimates of the completion costs of a EMD program.

D. THE RAYLEIGH DISTRIBUTION METHOD

1. Overview

The accuracy of a cost estimate is critical to the use of any method as a tool. Expenditures in developmental programs tend to follow a distinctive curve, often referred to as the Rayleigh Curve. This curve can be used to model natural events such as the growth of biological systems. Developmental projects tend to pattern this same type of growth during the lifecycle of the project. There are natural build-ups and build-downs in the level of resources consumed.

Norden used this curve in *Useful Tools for Project Management*, to model the costs and resource use of software development. Abernethy found the curve could accurately model the cost expenditure pattern of weapon system programs. Elrod examined the application of the curve in EMD programs using two different models and found that it fit. Lee, Hogue and Gallagher developed a technique using the Rayleigh Function to estimate Research and Development budget profiles. Gallagher and Lee developed a technique based on the Rayleigh model to provide probabilities for the estimate at completion. Substantial prior work has been accomplished that indicates the Rayleigh Function models actual expenditures well.

Here the Rayleigh model is used to estimate the ending costs of the A-12 program, had it continued to completion in EMD. Figure 2 provides a graphical representation of the cumulative expenditure curve that models developmental program expenditures.

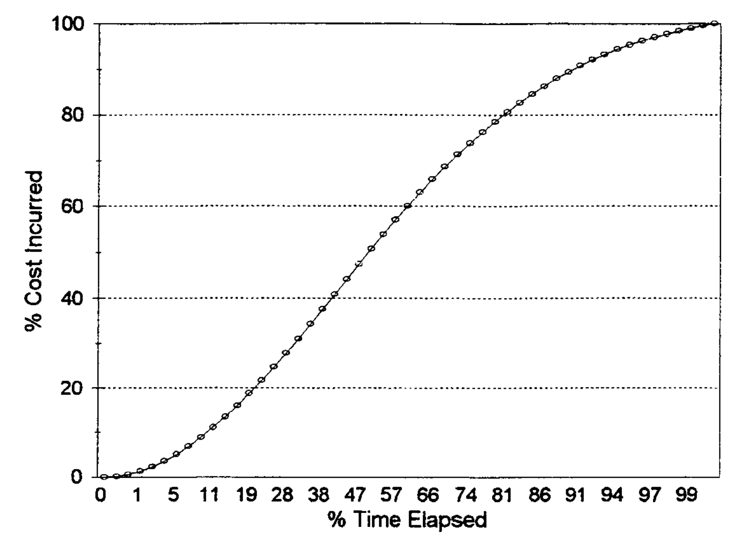

Figure 2. Typical "S" Shaped Rayleigh Curve. [Ref. 18]

2. Formulae

The general form of the Rayleigh cumulative density function is given by:

$$F(t) = 1\text{-}\exp(-\alpha t^2) \qquad (2.8)$$

Where a is a time-scale parameter and t is the time period. [Ref. 18] Equation (2.8) is adapted for use in developmental programs in the following function: [Ref. 18]

$$V(t) = d[1\text{-}(\exp(-\alpha t^2)] \qquad (2.9)$$

Where V(t) is the earned value at time t. d is a positive constant that is equal to the total budget of the project (D) divided by .97. [Ref. 18]

$$D = V(t_f) = .97d \qquad (2.10)$$

α is a constant that for EMD projects has been estimated to equal:

$$\alpha = 3.5/t^2_f \qquad (2.11)$$

With t_f equal to the final time of the project. [Ref. 18]

Often the final time of the project is not known with certainty. If the time of peak rate of expenditures is known or estimated, then α can be estimated by:

$$\alpha = 1/(2t^2_p) \qquad (2.12)$$

Where t_p is equal to the time of peak rate of expenditures. The time of peak rate of expenditures assumes added importance for programs such as aircraft or missiles which have scheduled first flight dates. It has been found that the peak rate of expenditure often occurs at the time of first flight. By taking the first derivative of equation (2.9) and setting it equal to zero, the time of peak expenditure rate, or first flight can be found. [Ref. 18]

$$V'(t) = 2\alpha t[\exp(-\alpha t^2)] \qquad (2.13)$$

Algebraic manipulation of equation (2.9) yields a formula for estimating the costs at completion, given a current ACWP at a specified time: [Ref. 18]

$$d = [\, V(t)/(1-\exp(-\alpha t^2))] \qquad (2.14)$$

E. APPLICATION OF THE RAYLEIGH FUNCTION TO THE A-12 PROGRAM

1. Overview

Early in this research the author realized that an appropriate tool for estimating costs at completion was needed. While common methods for estimating costs at completion involve the use of efficiency indices, this method was found to be inappropriate for estimations of completion costs when the CBB is subject to future changes. The CPI technique is based on the current budget and its estimates will be biased in this regard. The Rayleigh technique provides an estimate for what the future completion cost will be independent of current budgets.

2. Justification

Abernethy's previous work demonstrated a high correlation in the model's ability to provide ACWP estimates, given the final cost. Abernethy, concluded that while the Rayleigh Function could effectively model ACWP, given final actual costs, it was not a good predictor of final costs [Ref. 2]. The question then becomes is the Rayleigh method a better predictor of final cost than the CPI methods?

The Rayleigh Function was applied to a sample of 10 contracts using equation (2.14) to determine if the estimates at completion were closer than estimates using efficiency indices. An estimate at completion for each percentage completion point was computed using the Rayleigh Function, the Cumulative CPI, and a Weighted CPI. The total variance from the actual estimate at completion and the Rayleigh estimate showed an absolute difference much less than the two other methods, indicating a more accurate model.

Further refining the model by iteratively adjusting the shape parameters and establishing time bracket parameters resulted in even less variance in the Rayleigh estimates. The Rayleigh technique was able to achieve results that were 300 percent better than the Weighted CPI method and 200 percent better than the Cumulative CPI method. Elrod varied the alpha value of the model to determine a best fit to the data. In this research the alpha value is fixed at .00035 and the power of t from equation (2.14) is allowed to vary. The alpha value is able to be fixed at .00035 by standardizing all contracts to the same time period. This was accomplished by using percent completion points instead of months. Therefore every contract's time period consists of 100 and α remains constant at .00035.

To optimize the model to the data the alpha value can not be a constant. This was adjusted for by allowing the constant power of 2 for the power of ($-\alpha t$) to vary. In effect equation (2.14) becomes:

$$d = [V(t)/(1-\exp(-\alpha t^x))] \qquad (2.15)$$

Equation (2.15) was used to estimate the final cost of the A-12 Program. This equation varies from the original Rayleigh function by the addition of the variable x. The basis of the estimating technique remains equivelent to the Rayleigh methodology.

The constant power 2 was replaced by the variable x to allow the model to adjust based on the percentage completion the program had achieved. During the research hundreds of tests were conducted using the Rayleigh model and actual contract data. It was found that the Rayleigh model consistently overestimated the completion costs early in the program and late in the program. By fixing α and allowing the power of t to vary according to the percentage complete a significantly more accurate model was obtained. In the research the variable x was allowed to assume one of ten values corresponding to percentage complete brackets. The addition of this third variable to the function changes the essential characteristics of what is considered the Rayleigh model. A full examination of the effects of this addition are outside the scope of this research.

Gallagher refined the Rayleigh model using Multiple Model Adaptive Estimation (MMAE) [Ref. 14] to provide Bayesian statistical probabilities of outcomes for costs at completion. By refining the model in this method it provided cumulative probabilities of the Rayleigh produced completion costs. Gallagher's MMAE model is used in this research to provide cumulative probabilities of occurrence of the EAC for the A-12 program.

F. THE BETA DISTRIBUTION

Information on cost variances was collected from 58 developmental contracts. Based on the sample and the hypothesis to be tested, data from all 58 contracts were not used. The requirements that the data had to meet for each research question are contained in Chapter IV, Data.

The sample data did not approximate a normal distribution. In this research a cost overrun is considered a negative cost variance while a cost underrun is considered a positive cost variance. The distribution of these data was skewed to the left, with the mean close to zero and data points extending far into the left tail.

Using Best Fit [Ref. 20], the distribution that was most representative of cost overruns was the Beta distribution. The Beta distribution can assume many shapes based on the two parameters (v, w) that determine its shape. Figure 3 is provided to give the reader some insight into the degree to which the Beta distribution modeled the data. More information on the distribution of the data is contained in Appendix B.

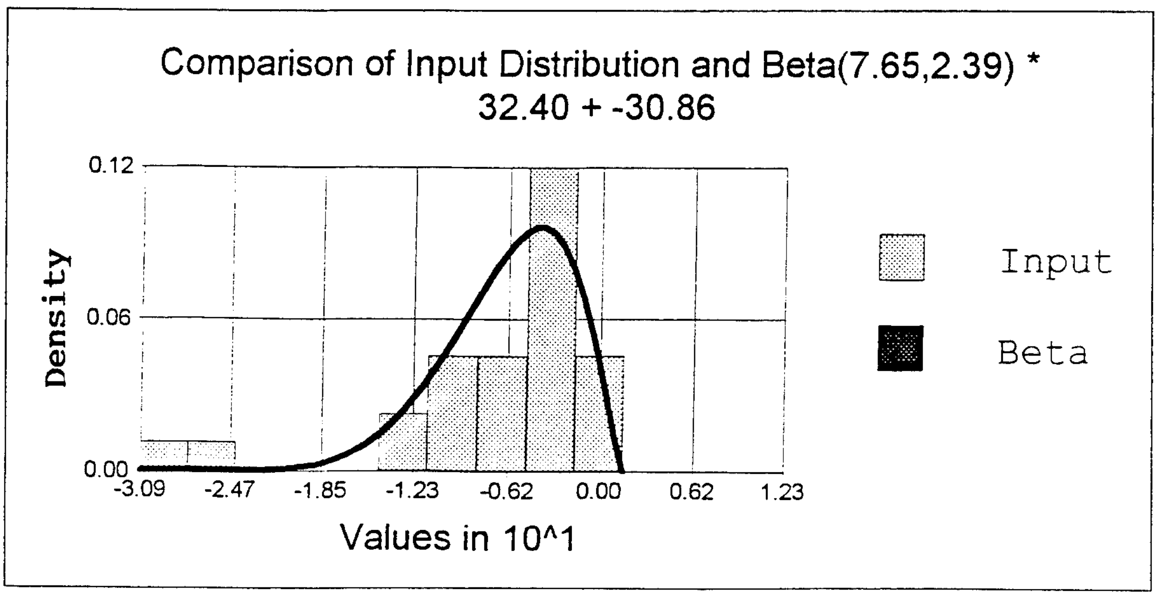

Figure 3. The Beta Distribution.

G. SUMMARY

This chapter provided an overview of the Acquisition Process and the C/S CSC terminology that will be used throughout this paper.

The technique used for obtaining EACs for the A-12 program was presented. While there are endless techniques for estimating completion costs, the Rayleigh model is used based on prior research and its ability to estimate costs independent of current budgets.

Cost variances are usually negative. The distribution of cost variances for the sample was skewed to the left. The Beta distribution tended to model cost overruns better than the Normal distribution. A graphical presentation of the Beta distribution is helpful in picturing the distribution of cost overruns.

Chapter III completes the background portion of this paper. Chapter III examines the A-12 Program and the cost variances that caused the termination of the Program.

III. THE A-12 PROGRAM

A. OVERVIEW

This chapter is intended to give the reader background information on the Navy's A-12 development program. As shown in Chapter II, cost overruns in defense acquisitions are not unusual. This chapter supports the primary research question by examining the A-12 Program and the cost overruns that occurred. For a more in-depth view of the A-12 Program the reader is referred to The Beach Report [Ref. 2], the Navy's internal review of the Program that was conducted in 1990.

B. MISSION NEED

The A-12 Avenger was designed to replace the A-6 Intruder in the Navy's carrier based fleet. Its projected survivability and adaptability would allow the Navy to also replace the EA-6B, Advanced Tactical System aircraft. The Navy also considered the air-to-air capability of the A-12 in possibly replacing the F-14s in the fleet defense role. The various roles that the A-12 could fill would provide a more streamlined logistical system by reducing the various spare parts that would be carried in inventory [Ref. 21]. The aircraft was to be a carrier-based medium range attack aircraft with low observable (stealth) characteristics. The United States Air Force (USAF) was interested in procuring up to 400 A-12 variants that would not require the structural hardening to land on aircraft carriers. The Air Force's version was planned to be the replacement for the F111. The Air Force planned on taking initial delivery in 1995. [Ref. 9]

The first version of the A-6 entered the fleet in 1963 as an all weather, day/night medium attack aircraft. The latest version of the A-6, the A-6E, was introduced in 1972 and procurement continued through 1987. In the 1980's wing cracks began appearing in the inventory of the A-6s. The stress of landing on carriers required that when the wings reached 67 percent of their life, the plane was limited to restricted duty until the wings were replaced. By 1988, most of the inventory of A-6s was rapidly degrading. In 1988, the year the contract for the Full-Scale Development of the A-12 was awarded, the Navy placed its last production order for the A-6. The A-12, with an Initial Operational Capability (IOC) of 1994, was to replace the A-6s. The first squadron was projected to be combat ready by late 1996 [Ref. 21]. Figure 4 shows the projected A-12 aircraft superimposed over the F-14 and the A-6.

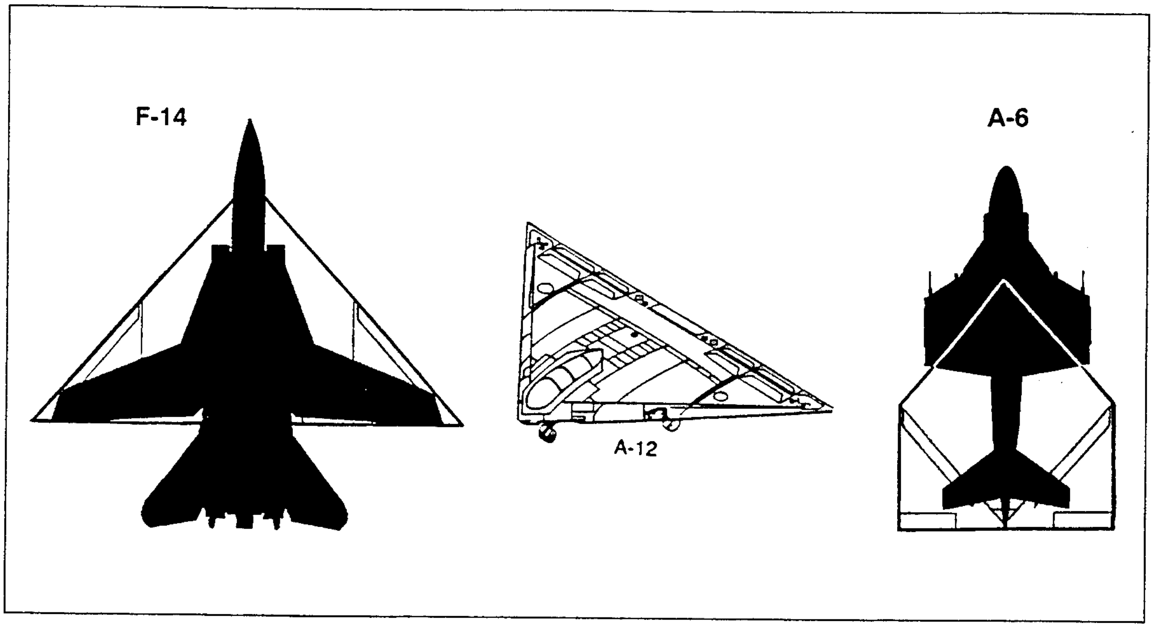

Figure 4. Aircraft Comparison. [Ref. 21]

C. EARLY DEVELOPMENTAL WORK

In 1984 Concept Exploration work began on the A-12 Program. The F-117 Stealth Fighter proved the validity of stealth technology. The F-117 was operational for one year with the USAF in the Nevada Desert, however, it was still tightly classified. The early development work on the A-12 was also classified as a special access program.

In 1984, two separate contractor teams began concept exploration for the new aircraft. This Program was initiated in 1984 with the start of Concept Exploration. In June 1986 the same contractor teams were awarded contracts to continue work into Demonstration and Validation. In June 1986, Captain Lawrence Elberfeld was appointed as the Program Manager of the Program which was now in Phase I of the Acquisition Process. Captain Elberfeld participated in the source selection for the A-12. Phases 0 and I of the acquisition cost $2.8 billion. [Ref. 25]

D. FULL-SCALE DEVELOPMENT

1. The Contract

The FSD contract was awarded to McDonnell Douglas/General Dynamics in January 1988. The contract was a Fixed-Price-Incentive-Firm type contract with a share ratio of 60/40 above contract target cost. The target price was $4.379 billion, the target cost was $3.981 billion and the ceiling price was $4.77 billion [Ref. 9]. On any overruns above target cost, from $4.4 billion to $4.8 billion, the Government would pay 60 cents of every dollar and the contractor would pay 40 cents. The Point of Total Assumption was $4.65 billion. Progress payments to the contractor were approved at the 80 percent rate.

The contract required the full-scale development and prototype production of the aircraft. The original first flight was scheduled for June 1990. This date was adjusted several times throughout contract performance, until just prior to termination the projected first flight date was March 1991. The time of first flight in an aircraft development contract is of crucial importance in estimating cost expenditures. As was explained in Chapter II in more detail, the point of first flight is usually the point of peak expenditures of the program. Given this point the total cost of the contract at completion may be estimated. Historical data indicate that 40 percent of the development costs are expended at the point of first flight [Ref. 14]. The impact of delaying the first flight results in increased cost and extended development schedule [Ref. 18]. Table 2 provides the adjustments made to the scheduled first flight of the aircraft over the performance of the EMD contract.

1st FLIGHT DATE	DATE OF SLIP	SOURCE
17 June 1990		Contractually Specified
September 1990	November 1989	Nov. 89 DAES report
December 1990	March 1990	Contractor Brief to MAR Steering Committee
March 1991	May 1990	Contractor Brief to PM
December 1991	November 1990	Contractor request to restructure
June 1992	December 1990	CAIG estimate submitted to the DAB

Table 2. A-12 First Flight Adjustments.

The contract also required delivery of "eight flight test aircraft and five full-scale ground test articles..." Additional provisions of the contract provided for three production option lots of 4, 6, and 16 aircraft, and an option for a fourth production lot at the completion of the Critical Design Review. The first two production lots were for pilot production and the third and fourth lots were low rate initial production. [Ref. 9]

2. Costs

Initial cost estimates were based on the purchase of 858 total aircraft at an annual procurement rate of 48 aircraft. With the reduction of the fleet to 14 aircraft carriers the requirement for A-12s dropped to 620 aircraft purchased at an annual rate of 36.

The cost of the A-12 was initially projected to be $86.6 million per aircraft, given a production rate of 48 per year. When the requirement dropped to 36 aircraft per year, the cost per aircraft increased to over $100 million per aircraft. The Lot I pilot production was priced at $1.2 billion for 6 aircraft [Ref. 24]. As production continued and the quantity produced increased with the anticipated USAF demand, prices were expected to fall, according to Learning Curve theory.

A graphical cost comparison of the A-12 to other combat aircraft is shown in Figure 5. Costs shown are adjusted to 1995 dollars using Department of the Navy inflators. All data are drawn from *U.S. Weapon Systems Costs* [Ref. 5].

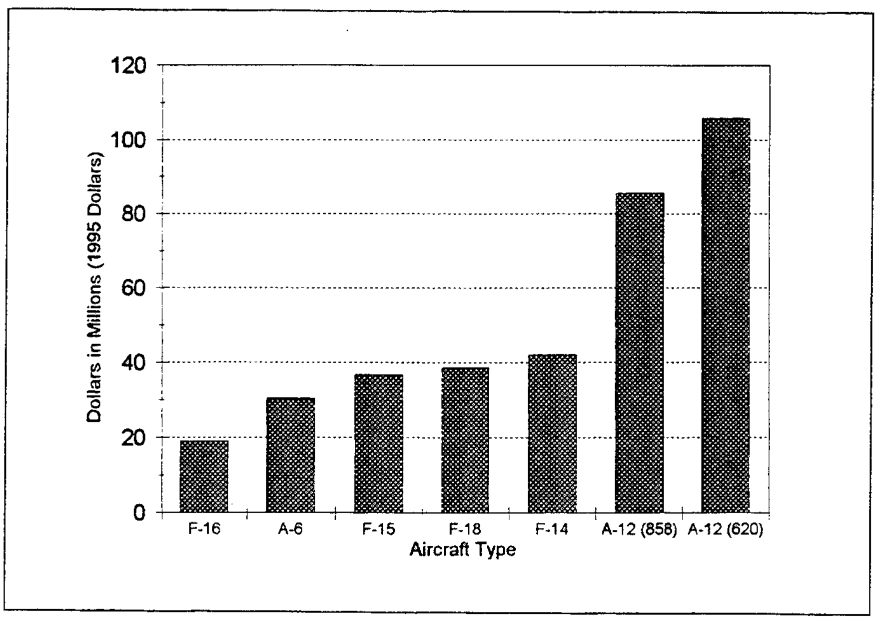

Figure 5. A-12 Cost Comparison. [Ref. 5]

The cost data presented are from 1975 to 1995, and adjusted to 1995 constant dollars using Department of the Navy inflator values. As shown, the cost of the A-12 would have been significantly higher than other aircraft in the inventory. The cost data for the F-117 are still restricted, so no comparison can be made to other stealth fighter aircraft.

3. Costs at Completion

The decision to terminate the A-12 Program was based on the cost overruns that the Program was experiencing and the uncertain estimate of costs at completion. The Secretary of Defense stated that the inability of being able to determine the final cost of the Program was a primary reason for the termination.

The cost at completion is driven by the first flight date. As the programmed first flight of the aircraft is extended, total program time is extended and the costs increase. The difficulty of determining a final cost is highlighted in Table 3. Table 3 provides final cost estimates of the Program determined by the Department of Defense Inspector General (DoD IG).

IF 1ST FLIGHT IS:	AND % COMPLETE AT 1ST FLIGHT IS:		
	40	50	60
JUNE 91	$14.28 B	$11.42 B	$9.52 B
DEC 91	15.86	12.69	10.58
MAR 92	17.36	13.88	11.57

Table 3. DoD IG Estimates at Completion. [Ref. 9]

The DoD IG estimates were prepared by the Cost Analysis Improvement Group (CAIG). The CAIG estimates provide EACs based on three possible first flight dates and three possible percentage completion points. The June 1991 first flight date is the most optimistic date. The range of values is based on assumptions of the percentage of the programs that would be complete at first flight, with 60 percent being the most optimistic.

4. The Contractors

The solicitation for the A-12 required a teaming arrangement. A teaming arrangement is intended to provide two qualified contractors for production to reduce unit costs. When the FSD phase of the A-12 contract began 10 U.S.C. 2438 required the Department of Defense to establish at least two competitive sources for production. This law was later amended in November of 1990. [Ref. 23]

The purpose of a teaming arrangement is to avoid reliance on a sole source of production for the system. Each contractor is to provide his particular area of expertise for the program and have the capability to independently produce the system after development. In the A-12 Program, the contractors established a written agreement that provided each team member would try to convince the Navy to guarantee a minimum of 40 percent of the production to each team member. When the requirement for the A-12s was reduced to 620 aircraft a competitive production contract was not feasible.

According to a General Accounting Office (GAO) report issued in 1992, "...an award split other than 50-50 or 60-40 would have put the losing contractor out of the A-12 business." [Ref. 23: p. 7].

The larger member of the A-12 team, McDonnell Douglas, was created in 1967 with the acquisition of the financially troubled Douglas Aircraft Company by McDonnell Company. McDonnell Douglas has been the Nation's top prime contractor in all but one of the years from 1984 to 1994 [Ref. 8]. Its average share of the Department of Defense's prime contracts has averaged around 6 percent of the value of total contracts awarded. According to *Financial World* magazine McDonnell Douglas has a market value of $5.6 billion, 154th in value of all U.S. companies. In 1994 McDonnell Douglas had $13.3 billion in sales and $562 million in profits [Ref. 13].

McDonnell Douglas produces the F-15 Eagle, F-18 Hornet, C-17 Globemaster III, AV-8 Harrier, T-45 Goshawk, AH-64 Apache, and the Tomahawk and Harpoon missiles. It also has RDT&E contracts for electronics and communications equipment, along with missile and space systems. [Ref. 5]

The other member of the A-12 team, General Dynamics, has consistently been in the top ten Defense contractors for the past ten years. Its dollar value of prime contracts has ranged from $2 billion to $8 billion. Its market value is $2.75 billion, placing it at number 329 of the nation's top companies. In 1994 it had $3 billion in sales and $214 million in profits. [Ref. 13]

General Dynamics produces the F-16 Falcon, the Seawolf nuclear submarine, M-1 tank, Tomahawk missile, Stinger missile, RIM-66 missile and the MK-15 Close in Weapon System. [Ref. 5]

Both companies have a history of litigation actions with the Government. They currently are contesting the $1.35 billion in unliquidated progress payments demanded by the Government and they have a certified claim for equitable adjustment for $1.4 billion resulting from the termination of the A-12 Program [Ref. 28, July 27 1994]. A ruling in December 1994 that vacated the Department of Defense's Termination for Default was considered a victory by the contractors in their efforts to clear their financial debt to the Government on the A-12 Program.

E. TERMINATION

1. Overview

The A-12 Program was terminated for default on 7 January 1991. The Secretary of Defense directed the Navy to terminate the troubled Program. Although many reasons contributed to the termination of the Program, this research is primarily concerned with the stated reason for termination: cost overruns. The estimate at completion for the A-12 varied significantly. The Secretary of Defense stated uncertainty in estimating the cost of the contract was the primary reason for terminating the Program.

> This program cannot be sustained unless I ask Congress for more money and bail the contractors out, but I have made the decision that I will not do that. No one can tell me exactly how much more money it will cost to keep this program going. I do not believe a bailout is in the national interest. If we cannot spend the taxpayers' money wisely, we will not spend it. [Ref. 22: p. 3]

2. Costs at Termination

The cost of the work accomplished in the A-12 Program is difficult to estimate accurately. Under a fixed-price type contract the contractor is required to provide a deliverable to the Government. The Government will pay for the products or services it has accepted.

In the A-12 Program, the value of the work accomplished was priced at $1.34 billion. The contractors had incurred much greater costs in the development of the aircraft. Table 4 provides a detailed accounting of work accepted by the Government at termination.

ITEM	Price (In Millions)
Initial Design Review	269.8
Preliminary Design Review	261.9
Critical Design Review (Engine)	139.0
Critical Design Review (Phase IA)	150.6
Phase 1A Test Review	197.0
Program Management Review	316.3
Total	**$1,334.7**

Table 4. Value of Work Accepted. [Ref. 26]

While the value of work accepted was priced at $1.33 billion, the actual price paid for the work was $2.69 billion. Of this $2.69 billion the Government has demanded $1.352 billion in unliquidated progress payments be returned. The contractors are currently disputing the decision of the Government of the value of work accepted. [Ref. 25].

Total expenditures on the A-12 Program exceeded the value of the work accepted at termination. Table 5 provides a listing of expenditures on the A-12 Program at the point of termination.

CATEGORY	$ (Billions)
Total Appropriations	6.7
Total RDT&E Expenditures	2.85
FSD Contract Expenditures	2.58
Long Lead Procurement	0.104
Value of Work	1.34
Unliquidated Progress Payments	1.35

Table 5. A-12 Program Expenditures. [Ref. 26]

3. Contractor Claims

The contractors have an immense financial interest in the favorable settlement of the litigation. The conversion of the termination, from default to convenience, would completely restructure the settlement amounts.

The contractor team has filed a claim for equitable adjustment of $1.4 billion. The contractors claimed that the contract could not be completed according to the contractually specified terms because of:

1. The Navy's superior knowledge of facts vital to performance.
2. Delays and disruptions caused by the Navy's conduct.
3. The Navy's flawed acquisition strategy.
4. Commercial impossibility of performance.

The $1.35 billion demanded by the Government has been deferred pending the outcome of the litigation. [Ref. 25]

F. THE JOINT ADVANCED STRIKE TECHNOLOGY PROGRAM

1. Overview

The Navy committed seven years and $2.985 billion to the A-12 Program. If the contractors are successful in their litigation the cost of the A-12 Program to the Government could go as high as $6 billion. At the termination of the Program the Navy had very little that it could use in a future development program. During hearings by the Committee on Armed Services of the House of Representatives on the A-12 termination, Congressman Sisisky called the termination of the A-12 Program "..a national disaster with naval aviation."

2. The Next Fighter

The cost of developing a fighter aircraft to fulfill just the Navy's needs is prohibitively expensive. A joint program with the Air Force is currently ongoing called the Joint Advanced Strike Technology Program (JAST).

The JAST aircraft is being designed as a low observable technology aircraft that is projected to replace the Navy's A-6, the USAF's F-16 and the Marines AV-8. While the JAST aircraft will not have the ordinance carrying capacity that was provided by the A-6, this shortcoming is expected to be made up for in its use of smart weapons and increased survivability.

The JAST Program started in 1994 and is currently in Phase 0 of the acquisition process. It is expected to start EMD in the year 2000, Low Rate Initial Production (LRIP) in 2005, and Initial Operational Capability by the year 2007. [Ref. 16]

The total cost (life cycle cost) of the Program is expected to range from $160 to $200 billion. Unit procurement costs are expected to be from $30 to $40 million. This figure is relatively inexpensive when compared to the cost of other currently operational combat aircraft (See Figure 5).

The JAST aircraft is being conceived of as a modular aircraft that will utilize a common fuselage and Service unique components would then be added on. According to the Program Office, 85 percent commonality of parts is the goal. [Ref. 16]

The Mission Need Statement and the Operational Requirements Document from the A-12 Program were used as the base for developing the MNS and ORD for the JAST Program. The Program Manager is an O-7. The duties of Program Manager will rotate between the USAF and the Navy. [Ref. 16]

G. SUMMARY

Chapter III provided a short summary of the A-12 Program. The Program generally followed the basic Acquisition Process outlined in Chapter II. Although the A-12 was a restricted access program it was still subject to oversight. Shortly after the start of the FSD contract the Program started incurring cost overruns. As the Program continued the overruns became worse.. The uncertainty in the estimates of final completion costs resulted in the termination of the Program.

Chapter IV presents comparison data of other EMD programs and cost variances. These data are used to contrast the A-12 cost variances and determine if the A-12's overruns were different than other major acquisitions.

IV. DATA

A. OVERVIEW

This chapter provides the data that are used to answer the primary research question: Was the A-12 Program over cost when compared to other similar acquisitions? Chapter IV begins by providing the actual reported cost data for the A-12 Program up to the point of contract termination. Data from 58 comparison contracts are then provided as the sample to be tested against.

There are hundreds of contracts in the DAES database. The selection of the contracts used in this research conformed to the requirements set out in Chapter I, with a few exceptions. Sixty-five EMD contracts were initially drawn from the database. Seven contracts were eliminated from the sample due to excessive rebaselining or insufficient data points. Three contracts were retained that did not meet the ten data point requirement. These contracts were for aircraft development and met the other specified requirements for inclusion.

It became apparent, as this research was conducted, that all programs experience adjustments to the Contract Budget Base (CBB). In the 58 contracts examined for comparison with the A-12 Program only two contracts showed a downward adjustment in the CBB. In one case the program's funding was reduced by nearly half, the other contract showed a cost at completion that was just slightly under the original estimate.

The effects of inflation do not account for the upward revisions. Contractor expenditure budgets are based on future predictions of price escalation. This was confirmed by a former program manager of Lockheed Corporation and a Cost Analyst with the CAIG. The explanations for the adjustments to the CBB can include poor original understanding of the scope of work, or adjustments to the contractual requirements. Regardless of the cause, only five of the 58 contracts examined finished the EMD phase within five percent of the original CBB.

B. A-12 PROGRAM COST DATA

1. Program Information

The A-12 Program began the EMD phase in January 1988. Significant effort on the Program was expected to be complete by April 1996, with first flight of a prototype aircraft in June 1990. During the life of the A-12 Program, 27 Cost Performance Reports and nine Selected Acquisition Reports (SAR) were submitted. The data from the A-12 Program will be compared to the sample 58 contracts to determine if the A-12 cost variances were within the population of cost variances.

The comparison between the A-12 cost variances and the sample is based on cost variance at several percentage completion points. Table 6 provides the reported A-12 cost information.

REPORT DATE	BCWP	ACWP	% CV	% COMPLETE	CBB
Sept 1988	303.2	325.6	-7.39	7.6	3981.1
Dec 1988	441.7	494.5	-11.95	11.1	3981.1
March 1989	594.6	689.4	-15.94	14.9	3981.1
Sept 1989	1009.6	1220.5	-20.89	25.4	3982.2
Dec 1989	1279.2	1597.1	-24.85	31.6	4042.3
Apr 1990	1491	1950	-30.78	36.8	4046.4
June 1990	1704.4	2285.5	-34.09	42.1	4047.1
Sept 1990	1881.5	2611	-38.77	46.5	4044.7
Nov 1990	1990.6	2789	-40.11	49.2	4045

Note: Figures are reported in millions of constant dollars.

Table 6. A-12 Reported Cost Information.

The A-12 cost data are drawn from the nine submitted Selected Acquisition Reports. The percent complete and the percent cost variance are as reported. The Program was terminated in January 1991. The accuracy of the reported cost data is of great importance in determining whether the A-12 Program differed significantly from other similar programs.

2. Accuracy of Reported Cost Data

The accuracy of the A-12 ACWP data can be affected by numerous factors. There is delay from the time work has occurred to when it is reported. There can also be material understatements of the actual cost of the work performed.

During the EMD phase of the A-12 Program, McDonnell Douglas was experiencing cash flow problems [Ref. 15]. Significant cost variances reduce the amount of the progress payments based on estimates at completion. A reduction in the amount of the progress payments made to McDonnell Douglas would have had a negative financial impact in what was already a poor financial climate for the contractor. Incentives exist to under report cost information on an over-budget program, or to shift costs from an over-budget program to a within-budget program.

Evidence of McDonnell Douglas shifting costs from the A-12 Program to other Government contracts was reported in the September 11, 1995 edition of the Wall Street Journal. According to the article, the U.S. Justice Department has decided to litigate a whistle blower case. It is alleged, "...company supervisors systematically ordered assembly-line employees to improperly shift untold millions of dollars of labor costs between various weapons programs, including the C-17 cargo plane, F-18 fighters and the Navy's now-cancelled A-12 carrier based stealthy attack jet." The article further states that the C-17 and the A-12 were "the biggest beneficiaries of the alleged cost shifting." The amount of money involved is in the hundreds of millions of dollars. [Ref. 28, 11 Sept. 1995]

No correction can empirically be made to the actual reported costs for the Program. If the ACWP figures have been understated it can not be shown within the bounds of this research, and the impact it may have had on the Program is also out of the scope. An assumption is made that cost shifting may occur in any given program and no adjustment is made to the data.

3. The Problem of Rebaselining

The percentages complete of the A-12 Program as shown in Table 6 is based on a Contract Budget Base of $3.98 to $4.05 billion. Since the contract would have exceeded the ceiling price of $4.7 billion the Program would have been rebaselined if it had continued to completion. No significant adjustments were made to the CBB in the A-12 Program. In all the comparison contracts some degree of rebaselining occurred, in many cases the amount of the rebaseline was quite significant. Table 7 shows the average percentage adjustments in the sample program's CBBs. For contract information, the reader is referred to Appendix A. To determine the CBB adjustments a relatively large percentage of the program had to be complete. The percentage was determined to be data points covering at least 50 percent of the total program, and a program completion point achieved of at least 70 percent. The adjustment is determined by measuring the difference between the initial CBB and the ending CBB.

	MEAN	MEDIAN	MAX	MIN	N
Fixed Price	44%	54%	120%	-61%	8
Cost Type	57%	45%	232%	-4%	22
Aircraft	94%	99%	232%	4.15%	6
Total Sample	54%	46%	232%	-61%	29

Table 7. Contract Budget Base Adjustments.

Adjustments to the CBB have two major affects on the reported cost information. First, the percentage completion is reduced based on the new budget. Second, the cost variance percentage changes, based on the new BCWP figures.

Both affects impact the ability to estimate final completion costs accurately. Adjustments to the contract's budget can be made for a variety of reasons. The more stable the baseline, the more accurate the estimate at completion will be.

Table 8 provides adjusted percentage completion points of the A-12 Program based on three time estimates to complete.

ESTIMATED 1ST FLIGHT	ESTIMATED COMPLETION DATE	K LENGTH (Mo's)	AT TERM % COMP	EAC
June 1990	Apr 1996	100	49	4777
June 1992	Sept 1999	142	24	9069
Dec 1992	Jan 2001	158	21	11061

Note: Figures are reported in millions of constant dollars.

Table 8. Rayleigh Model Estimates of A-12 Program Expenditures.

The first time estimate is the contractually specified first flight and contract length. The second and third estimates are based on estimates of the first flight date, at contract termination. The first flight dates were obtained from Reference 9. The first flight date, in months from program start, is multiplied by 2.65 [Ref. 18] to estimate the total program length. The estimates at completion were derived using the Rayleigh model methodology described in Chapter II. The percentage complete at termination is determined by taking the termination cost of the A-12 and dividing it by the EAC. The EAC is based on an assumption of 40 percent of costs incurred at first flight.

4. The Estimate at Completion

The accuracy of using the Rayleigh model to estimate cost at completion was tested by Elrod [Ref. 11]. Elrod found a generally good fit between the Rayleigh model and actual costs at completion. Gallagher, a cost analyst in the Cost Analysis Improvement Group (CAIG), further developed this technique [Ref. 14].

The Rayleigh model's predictive capability was tested against ten aircraft program contracts. A comparison was then made using the CPIcum technique to determine the more accurate predictor. The results of this test are provided in a graph in Figure 6.

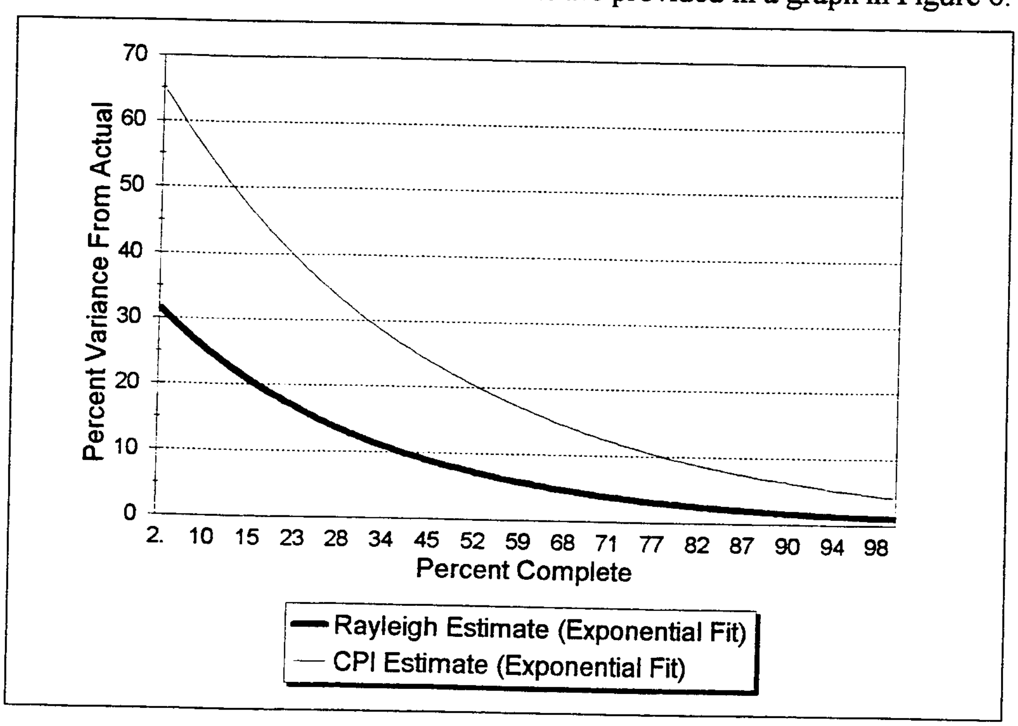

Figure 6. Rayleigh Model Versus CPIcum.

As shown in Figure 6, the Rayleigh estimates provide significantly less variance from actual completion costs over the life of the program. To derive the curves in the graph, data points from all ten programs were plotted against time and an exponential curve was fit to the data. Generally, past the 20 percent completion point, the Rayleigh model provides reasonable estimates of actual program completion costs. The percentage cost variances are within 10 percent of actual ending costs at the 40 percent completion point. Using the CPIcum technique, the estimates are not within 10 percent of actual ending costs until the 80 percent completion point. On the basis of Elrod and Gallagher's work, and the test against ten actual contracts, the Rayleigh model is accepted as providing a realistic estimate of A-12 Program costs.

5. Likelihood of the Estimates

An estimate of a future occurrence is by definition uncertain. It is of interest to be able to say with what probability the outcome will occur. The estimates of the final cost of the A-12 Program in Table 8 were tested using a software program developed and provided by Gallagher [Ref. 14] to determine the likelihood that the ending cost estimate would occur. Gallagher's work uses past cost figures to develop a Bayesian probability of future occurrence of the ending cost. He developed this technique while working as a cost estimator with the CAIG.

Three estimates at completion were tested using Gallagher's model. The first estimate was the Program Manager's EAC at contract termination. The second and third estimates were the EACs produced by the Rayleigh model for first flight dates of June 1992 and December 1992. Table 9 gives the probability that final ending costs would exceed the estimate. For a detailed explanation of the development of the probabilities and the Rayleigh estimates, the reader is referred to *Final-Cost Estimates for Research & Development Programs Conditioned on Realized Costs* by Mark A. Gallagher and David A. Lee [Ref. 14]. The article is available through the Defense Technical Information Center database.

1ST FLIGHT	PROBABILITIES OF EACs			
	P(X>=4.7B)	P(X>=7.5B)	P(X>9.07B)	P(X>=11B
June 1992	0.99	0.84	0.63	0.37
Dec 1992	0.99	0.87	0.70	0.49

Table 9. Probability of Final Cost Estimates.

In Table 9, the cumulative probabilities of occurrence of the given cost estimate are provided. The first column, 1st Flight, presents two possible first flight dates. These dates are drawn from the CAIG estimates provided to the DoD IG. Columns two through four provide four possible EACs and the probabilities of the Program exceeding the given EAC. The first EAC is the original ceiling price of the contract. The probability that the Program would have exceeded this ceiling is almost certain. If first flight would have occurred in December 1992, the probability that the Program cost would have exceeded $11 billion is .49.

To compute the probabilities shown in Table 9, two time assumptions are required. For a first flight date of June 1992, the minimum Program length was assumed to be five years from initiation with the maximum length of 13 years. If the first flight would have occurred in December of 1992, then the minimum length was assumed to be eight years with a maximum length of 15 years.

C. COMPARISON CONTRACT COST DATA

1. The Comparison Sample

Over 100 contracts were examined from the DAES database for inclusion into the sample. Sixty-five contracts were initially found to meet the requirements as specified in Chapter I: at least ten data points existed, the program had achieved a significant level of completion, and the program was classified as an ACAT ID program. Of the 65 contracts selected for comparison, five were eliminated due to non-consistency in completion percentages and two contracts were eliminated due to insufficient data.

2. Characteristics of the Sample

Fifty-eight contracts constitute the sample. To be included in the DAES database the program must be an ACAT ID program. All the contracts examined were for major programs. The completion points of the sample ranged from a low of 40 percent complete to a high of 100 percent complete. The average completion point achieved by the 58 sample contracts was 83 percent complete. Table 10 shows the characteristics of the sample examined.

	FIXED PRICE	COST REIMB	TOTAL
ARMY	1	18	19
AF	13	7	20
NAVY	2	17	19
TOTAL	16	32	58

Table 10. Characteristics of the Sample.

3. Sample Data

The cost variances of the sample were determined using equation (2.3). All contracts that met the specified criteria in Chapter I were used. Not all the sample contracts had data points for each of the percentage completion points. For those contracts that had multiple data points within a percentage completion range, the cost variances were averaged to avoid weighting data from any one contract more than other contracts.

The data for the percentage completion brackets are each modeled seperately. Only the 0 to 10 percentage completion bracket exhibits the Normal distribution that one would expect if cost variances were distributed about a mean cost variance of zero.

Table 11 provides the cost variances observed in the sample contracts. In Table 11, the completion point refers to the percentage complete the program has achieved measured by time expended divided by total time. Column 2 gives the arithmetic mean of the sample. The data are skewed to the left. The median is provided as a reference point. The sample of all 58 contracts is modeled by the Beta distribution. Column 4 indicates the distribution that modeled the data using a Chi-squared test.

COMPLETION POINT	MEAN	MEDIAN	TYPE DISTRIBUTION	N
0-10%	+1.78%	+1.68%	NORMAL	29
11-20%	-6.35%	-2.68%	BETA	37
21-30%	-5.27%	-2.75%	LOGISTIC	34
31-40%	-8.18%	-4.88%	LOGISTIC	37
41-50%	-11.16%	-6.95%	LOGISTIC	43
51-60%	-10.23%	-4.23%	LOGISTIC	43
61-70%	-10.59%	-3.85%	BETA	42
71-80%	-14.52	-6.68%	BETA	45
81-90%	-13.08%	-7.02%	BETA	39
>90%	-11.16%	-4.93%	BETA	27
ALL	-13.37%	-6.09%	BETA	40

Table 11. Cost Variances of Sample Contracts.

4. Aircraft Program Data

Seventeen contracts were included in the aircraft cost variance sample. Three contracts for aircraft developmental work were included in the sample that had only nine data points. To be included in the sample the program had to show relatively increasing degrees of completion as work progressed. The aircraft program contracts consisted of the contract for the program itself or for major aircraft type subassemblies. Contracts for subassemblies such as avionics, engines or armaments were not considered. Contracts for follow-on developmental work were also not included. Helicopters were considered as aircraft.

Of the 19 contracts initially examined only one program was terminated. The remaining programs continued into production or are still in the EMD phase. The one program that was terminated was later restarted under a different designation. This contract was not considered for inclusion since many of the technical problems that caused the original termination would have been paid for and would not have shown up in the new ACWP figures. Table 12 provides the mean and median cost variances of EMD aircraft programs.

COMPLETION POINT	MEAN CV	MEDIAN CV	N
0-10%	-2.99%	-.4%	11
11-20%	-8.12%	-5.18%	11
21-30%	-4.05%	-2.51%	12
31-40%	-8.38%	-5.34%	14
41-50%	-13.58%	-8.17%	10
51-60%	-12.51%	-8.99%	12
61-70%	-16.88%	-8.15%	12
71-80%	-16.79%	-11.33%	13
81-90%	-11.96%	-6.09%	10
>90%	-17.93%	-9.01%	8
ALL	-18.4%	-6.13%	17

Table 12. Aircraft Program Cost Variances.

The mean cost variance for all aircraft programs examined was -18.4 percent. The median value was -6.13 percent. Seventeen programs were included in the sample.

5. Fixed-Price Versus Cost-Type Contracts

All contracts that had exceeded 50 percent complete were included in the sample. The mean cost variance for all programs examined was -16.5 percent. Table 13 provides comparison data for mean overruns of fixed-price type contracts versus cost-type contracts.

TYPE CONTRACT	MEAN CV %	MEDIAN CV %	N
FP	-21.02%	-10.2%	15
COST	-14.76%	-6.05%	39
TOTAL	-16.5%	-6.78%	54

Note: Total=Most recent cv for contracts > 50% complete.

Table 13. Fixed-Price Versus Cost-Type Contract Cost Variances.

D. SUMMARY

This chapter presented the data to be used in Chapter V to determine if the A-12 Program was significantly different from other EMD programs. The difficulty of developing accurate estimates at completion is caused by several factors such as rebaselining, changes, or extensions of program length. The mean cost variance of EMD programs is -16.5 percent with a median value of -6.78 percent. While the median value for cost variances does not appear to be too significant, the true cost variances are masked by adjustments to the CBB. The mean adjustment to the CBB is 54 percent with a median value of 46 percent.

Adjustments to the CBB and cost variances are evaluated in Chapter V. Chapter V tests the hypothesis that the A-12 Program cost variances were no greater than other EMD programs. The next chapter also examines secondary causes for the termination of the A-12 Program.

V. DATA ANALYSIS

A. OVERVIEW

Chapter IV presented the data from 58 separate EMD contracts. Chapter V establishes percentile values for the sample programs and compares the A-12 Program cost variances. Initially, the A-12 is compared to the entire sample for differences. The A-12 cost variances are then compared to other aircraft programs.

B. A-12 COST VARIANCES

1. Percentile Values

To provide a valid comparison of the sample data and the A-12 cost variances, the cost variances of the sample are grouped by percentage completion points. Percentile values are determined for each sample point based on the type of distribution. The procedure to accomplish this was to use the statistical software program, Minitab [Ref. 19]. The Inverse CDF command returns the percentile value for the specified point. With the Beta distribution the critical value is a value from 0 to 1. This value is converted to the actual value using techniques described in Appendix B. Table 14 provides the percentile values for the designated percentage completion points.

% COMPLETE	TYPE DISTRO	PARAM 1	PARAM 2	CHI SQD VALUE	95th PERCENTILE VALUE	99th PERCENTILE VALUE
0 - 10	Normal	1.79	11.56	17.56	-17.22	-25.1
11 - 20	Beta	2.3	1.07	16.54	-23.85	-29.33
21 - 30	Logistic	-5.27	6.08	26.84	-23.17	-33.21
31 - 40	Logistic	-8.08	5.54	26.04	-24.39	-33.53
41 - 50	Logistic	-11.02	8.08	49.92	-34.81	-48.15
51 - 60	Logistic	-9.99	7.81	37.77	-32.98	-45.88
61 - 70	Beta	1.67	1	25.25	-66.04	-75.2
71 - 80	Beta	2.53	1.18	38.33	-46.29	-56.23
81 - 90	Beta	1.93	0.78	13.11	-49.66	-60.19
>90	Beta	1.06	0.22	10	-37.52	-47.73
All>80%	Beta	1.49	0.82	21.34	-46.98	-53.65

Table 14. Percentile Values for the Sample Contracts.

The data from Table 14 are used to answer the primary research question and Hypothesis 1: Point values of the A-12 are no different from cost variances of the sample. The first column of the Table provides the percentage completion points of the sample contracts. Column 2 provides the distribution that best modeled the data, the resulting Chi-squared value is in Column 5. The parameters associated with the distribution are in Columns 3 and 4. For the Normal distribution, the parameters are given by the mean and standard deviation. The percentile values are the area of the distribution above the given value.

2. A-12 Cost Variance Percentiles.

After determining the critical values in Table 14, the next step was to evaluate where the A-12 cost variances were in relation to the distribution. Table 15 provides the comparison of A-12 cost variances versus the sample.

% COMPLETE	% CV	TYPE DISTRO	AREA ABOVE VALUE
7.6	-7.39	Normal	0.7907
11.1	-11.95	Beta	0.7305
14.9	-15.94	Beta	0.8257
25.4	-20.89	Logistic	0.9288
31.6	-24.85	Logistic	0.847
36.8	-30.78	Logistic	0.9837
42.1	-34.09	Logistic	0.9456
46.5	-38.77	Logistic	0.9688
49.2	-40.11	Logistic	0.9734
vs.samp	-40.11	Beta	0.9108

Table 15. A-12 Cost Variance Percentile Values.

The results from Table 15 agree with prior work by Heise [Ref. 18], Christensen [Ref. 3], and observations made by Abba and Christle. As the program proceeds the cost overrun does not improve.

In Table 15, Columns 1 and 2 are the percentage completion points and cost variance as reported. The distribution that modeled the data is in Column 3. The final Column provides the percentage of programs that the A-12 cost variance exceeded.

The A-12 cost variances exceeded 75 percent of sample programs at the 7.6 percent completion point. The cost variances worsened from that point on. Given Heise's earlier findings that the CPIcum will remain stable from the 20 percent completion point on, it is unlikely that the cost variances of the A-12 would have improved, if the program had continued. The relation of the A-12's cost variances to other programs did not improve. At termination the cost variance of the A-12 exceeded 97 percent of all other programs. As shown from the sample data, the A-12 cost overruns were exceptional.

C. AIRCRAFT PROGRAMS

1. Aircraft Program Percentile Values

In Table 16, aircraft program cost variances are examined to determine if A-12 cost variances differed from other aircraft programs. The same analysis techniques were used as with the comparison to the overall sample.

% COMPLETE	TYPE DISTRO	PARAM 1	PARAM 2	CHI SQD VALUE	95th PERCENTILE VALUE	99th PERCENTILE VALUE
0-10	Beta	1.75	0.83	9.04	-16.33	-19.85
11-20	Beta	1.17	0.56	4.84	-24	-26.86
21-30	Beta	1.43	0.64	9.69	-11.65	-13.42
31-40	Beta	2.05	0.94	17.62	-23.06	-27.29
41-50	Logistic	-12.63	10.16	20.51	-42.54	-59.32

Table 16. Aircraft Program Percentile Values.

The sample of aircraft programs includes 17 separate contracts. Cost variances are determined for each percentage completion bracket. The data are modeled using BestFit [Ref. 20]. Appendix B contains complete information on rankings and selection of distribution types. Percentile values were determined using Minitab.

2. The A-12 Program Versus Sample Aircraft Programs

The reported A-12 cost variances and percentage completion points were compared to other aircraft programs to determine differences. The results are provided in Table 17.

% COMPL	% CV	TYPE DISTRO	AREA ABOVE VALUE
7.6	-7.39	Beta	0.736
11.1	-11.95	Beta	0.7112
14.9	-15.94	Beta	0.7968
25.4	-20.89	Normal	0.9997
31.6	-24.85	Beta	0.9708
36.8	-30.78	Beta	0.9955
42.1	-34.09	Logistic	0.8921
46.5	-38.77	Logistic	0.9291
49.2	-40.11	Logistic	0.9373

Table 17. A-12 Versus Sample Aircraft Programs.

The distribution that best modeled the data from the aircraft programs was used to compute the area under the cumulative density function (CDF) for the A-12 values. This was accomplished using Minitab and the CDF command.

The area given in Column 4 is the percentage of programs that the A-12 cost variance exceeded. At 7.6 percent complete, the cost variance in the Program exceeded 73.6 percent of other aircraft programs. At termination, the A-12 cost variance exceeded 93.7 percent of other aircraft programs. The data indicate that the A-12 Program cost variances were exceptional when compared to other aircraft programs.

D. FIXED-PRICE VERSUS COST-TYPE CONTRACTS

1. A-12 Cost Variances Versus Contract Type

This analysis is conducted to determine the degree to which the selection of a fixed-price contract may have effected the cost overruns in the A-12 program. The mean cost variance of a fixed-price contract is -21.02 percent. The median cost variance is -10.2 percent. Fifteen contracts were included in the sample.

The mean cost variance of cost-type contracts is -14.76 percent with a median value of -6.05 percent. Thirty-nine contracts were in the sample. Table 18 provides the results of a comparison between the A-12 cost variances and cost variances based on contract type.

TYPE SAMPLE	TYPE DISTRO	95th PERCENTILE VALUE	99th PERCENTILE VALUE	A-12 VALUE	AREA ABOVE A-12
FP > 50%	Logistic	-47.79	-51.75	-40.11	0.828
CP >50%	Beta	-42.73	-54.52	-40.11	0.9372

Table 18. Contract Type Comparison.

The data indicate there is a difference in the cost variances based on contract type. Compared to fixed-price contracts, 24 percent of programs experienced worse cost overruns while only 5 percent of cost-type programs experience worse overruns.

This apparent difference was investigated using the non-parametric Mann-Whitney test. This test determines if there is statistical difference between the mean of two populations. On the basis of the data, the test could not reject the null hypothesis that there was no difference, with alpha equal to .05. This would refute the apparent difference shown in Table 18. Statistically, there is insufficient evidence to claim there is a difference in the cost variances experienced by contract type.

2. Aircraft Programs Versus the Sample

A second investigation was made to determine if aircraft programs experience different overruns than the overall sample. The null hypothesis could not be rejected with alpha equal to .05. There is not sufficient evidence to claim there is a difference in aircraft program cost variances and the overall sample.

E. ADJUSTMENTS TO THE CONTRACT BUDGET BASE

1. The Sample

All programs examined experienced adjustments to the CBB. In only two of the 58 contracts examined was there a reduction in the CBB. The mean adjustment to the CBB is 53 percent with a median adjustment of 46 percent.

The effects of inflation were disregarded based on assumptions stated in Chapter I. Hypothesis 4 and 5 were tested using the Mann-Whitney test. For each test alpha was selected to be .05.

1. Hypothesis 4. $\mu_{cbbfp} = \mu_{cbbc}$
2. Hypothesis 5. $\mu_{cbbacft} = \mu_{cbbsample}$

The alternative hypothesis in each case was the means were not equal. For each test, the null hypothesis could not be rejected with rather strong evidence. This indicates there is no statistical difference in the adjustments to the Contract Budget Base of different types of programs or different types of contracts. It should be noted that while the means of the CBB adjustments appear to show a wide difference the tests conducted are based on the variances of the data. A summary of the tests and criterion are provided in Appendix B.

2. A-12 CBB Adjustments

Table 19 shows the EACs developed in Chapter IV for the A-12 program, and the percentage change required to adjust the original CBB to the EAC. This percentage adjustment is then compared to the distribution of the sample adjustments in CBB. A percentile value is determined based on the required adjustment to the A-12 CBB.

EAC	% ADJ REQD	TYPE DISTRO	VERSUS SAMPLE	TYPE DISTRO	VERSUS SAMPLE W/O ACFT
7500	57	Logistic	0.53	Normal	0.64
9069	89.8	Logistic	0.77	Normal	0.88
11061	131.5	Logistic	0.93	Normal	0.99

Table 19. Required CBB Adjustments.

Three EACs are shown in Column 1. The first is the PM's EAC at termination of the Program. The second and third EACs are the Rayleigh derived estimates presented earlier. The percentage adjustment that is required to increase the original CBB to the estimated EAC is given in Column 2. Column 3 is the distribution best modeling the distribution of CBB adjustments for the entire sample. In Column 4 is the percentage of programs that required a smaller percentage of adjustment to complete the EMD phase.

Columns 5 and 6 a comparison of the A-12 required adjustments versus the sample without aircraft included.

There were not enough data points for fixed-price programs or aircraft programs to provide a meaningful comparison.

3. Analysis

A CBB adjustment to increase the program funding to $7.5 billion would require a 57 percent increase in the CBB. A 57 percent increase would result in the program's adjustment being greater than about 53 percent of all other programs in the EMD phase.

A CBB adjustment to increase the program funding to $9.069 billion would have required a 90 percent increase in the CBB. This increase would have exceeded 77 percent of all other programs. The probability of the A-12 Program costing at least $9 billion is .70.

A CBB adjustment to increase the program funding to $11 billion would have required a 132 percent increase in the CBB. This would have exceeded 93 percent of all other programs. The probability of the A-12 Program costing at least $11 billion is .49.

F. COST VARIANCES OF EMD CONTRACTS

1. Results of the Research

This research examined fifty-eight total contracts. Table 20 summarizes the findings on cost variances in the EMD phase of the acquisition process.

SAMPLE	MEAN CV %	MEDIAN CV%	99th PERCENTILE	N
FIXED PRICE	-21.02	-10.2	-94.81	15
COST TYPE	-14.76	-6.05	-51.77	39
AIRCRAFT	-14.03	-6.13	-49.18	15
TOTAL	-13.63	-6.09	-51.26	40

Table 20. EMD Cost Variances.

2. Findings

Fixed-price contracts tend to have the highest cost variance of either contract type. The mean cost variance for fixed-price contracts is -21.02 percent. Cost-type contracts require the greatest CBB adjustment, 57.24 percent, compared to fixed-price contracts that require a 43 percent increase. Aircraft programs, in general, do not have exceptional cost variances, but they do require above average CBB adjustments.

G. SUMMARY

This chapter examined the data from the sample 58 contracts and compared the results to the A-12 Program. Compared to the sample contracts, the overruns in the A-12 program, at 41 percent over programmed budget, were exceptional. To increase the funding for the program would have required an increase of approximately $5 to $7 billion. This amount of CBB adjustment would have been exceptional as well.

The final chapter, Chapter VI, reviews the research questions and the findings.

VI. CONCLUSIONS AND RECOMMENDATIONS

A. REVIEW OF THE RESEARCH QUESTIONS

1. The Primary Research Question

Were cost overruns in the A-12 Program exceptional?

The answer to this question was intended to be a simple yes or no. In keeping with this intent the answer is yes. The cost variances in the A-12 program were exceptional when compared to the sample contracts in the EMD phase.

The justification for this finding is based on a comparison of the percentile values of the A-12 cost variances, measured against other programs at similar points of completion. Table 6, in Chapter IV, shows the cost variances of the A-12. Table 15 in Chapter V, provides the percentile values for the A-12 and the area of the distribution that exceeded the point values of the cost variances for the A-12. A test to see if the cost variances of the A-12 were no different than other aircraft programs was conducted and the same results were found. The results of the comparison to other aircraft can be found in Table 17, in Chapter V.

The A-12 cost variances clearly exceeded a majority of other program's cost variances. Compared to the sample of 58 contracts, the cost overrun of the A-12 exceeded 91 percent of the others. At termination, the A-12 exceeded 94 percent of other aircraft program's cost overruns. To ensure these results were not biased by the selection of the distribution, at least one different distribution was applied in each case to determine if like results would be obtained. In each case the cost variance's percentile value remained extreme. The comparison distribution's percentile values can be found in Appendix B.

Measurements of only the cost variances do not account for adjustments to the Contract Budget Base. A program with a large cost variance can be rebaselined to eliminate the variance. Ignoring the CBB adjustments would bias the findings. The impact of CBB adjustments was tested in the subsidiary research questions.

2. Subsidiary Research Questions

What would the A-12 FSD program have cost if it continued to completion?

It is likely that the program would have cost between $9 and $11 billion. Based on a Rayleigh model estimate at completion and the MMAE methodology developed by Gallagher, the costs and probabilities for the estimates at completion are as follows:

a. Given a June 1992, first flight date the program would have been completed in September 1999. The program would have cost $9 billion. The cumulative probability of the program exceeding this cost is .63.

b. Given a December 1992, first flight date the program would have been completed in January 2001. The program would have cost $11 billion. The cumulative probability of the program exceeding this cost is .49.

These results are consistent with the DoD IG estimates contained in Table 3, in Chapter III. The DoD IG estimates were prepared by the Cost Analysis Improvement Group.

The budget adjustments that would have been required to finish the program would have exceeded between 77 and 93 percent of all other programs. To eliminate the cost variance would have required an above average budget adjustment.

Was the Secretary of Defense justified in terminating the Program for cost overruns?

Yes. The cost variances in the A-12 Program exceeded 97 percent of all other programs, as shown in Table 15, in Chapter V. A budget adjustment between 89 and 132 percent would have been required to finish the program. While this amount of adjustment to the budget would be within the distribution of CBB adjustments, (See Table 19) it would have as a minimum exceeded 77 percent of all other Contract Budget Base adjustments.

Are there differences in cost overruns between aircraft programs and other types of EMD programs?

No. There is insufficient evidence to conclude that aircraft programs experience significantly different cost variances. The test results could not reject the null hypothesis that there were no differences. The test showed there was no statistical difference with alpha equal to .05.

Are there differences in cost overruns between fixed-price contracts and cost-type contracts for developmental work?

No. There is not sufficient evidence to claim that fixed-price contracts experience statistically different overruns. As measured by the Mann-Whitney non-parametric test, the null hypothesis could not be rejected with alpha equal to .05.

What is the average cost overrun of an EMD contract?

The mean cost overrun for an EMD contract is 13.37 percent, as shown in Table 20, in Chapter V. The mean cost overrun for aircraft programs is 14.03 percent. The mean cost overrun for fixed-price contracts is 21.02 percent and the mean overrun for cost-type contracts is 14.76 percent. The research found that the mean value for overruns tends to overstate the extent of the problem. The use of medians provides a more accurate picture. The median cost overruns for the above contracts ranged from 6.05 to 10.2 percent.

To examine the impact of rebaselining the percentage change in each contract's CBB was determined. The results of this examination are provided in Table 7, in Chapter IV. To eliminate the possibility that a normal rebaseline would have prevented the extraordinary overruns in the A-12 program, the required adjustment to the A-12's CBB was examined.

Depending on the date of first flight (assuming it would be no later than December of 1992), the required CBB adjustment is between 89 and 132 percent. An adjustment of this magnitude exceeds approximately 77 to 91 percent of all other programs. The required mean adjustments were found to vary dependent on program and contract type. The results of this investigation are provided in Table 19, in Chapter V.

There is insufficient evidence to believe that the adjustments to the CBB vary depending on either program type or contract type. The apparent difference in mean values for the contract types was investigated using the Mann-Whitney test. The test showed that the null hypothesis could not be rejected.

B. CONCLUSIONS

1. The Decision to Terminate the Program

The decision of the Secretary of Defense to terminate the A-12 Program was justified. The A-12 Program experienced significantly different cost variances from other programs examined. Hypothesis 1, the A-12 overruns were no different than other programs, was tested to determine if A-12 cost overruns were the same as other EMD contracts. This was not proven. At termination the A-12 Program was 41 percent overrun from its baseline. This amount of overrun exceeded 97 percent of other programs in the sample. The test compared percentile values of the A-12 versus the sample.

2. Fixed-Price Contracts and Cost Overruns

The assertion that the cause of the A-12's failure was due to the use of a fixed-price contract can not be supported by the data. The selection of contract type is not a factor in preventing cost overruns. The fixed-price contracts in the sample had a larger overrun than cost-type contracts, 21.02 percent versus 14.76 percent. The median overrun values were much closer: 10.2 versus 6.05 percent. Fixed-price contracts required smaller budget adjustments than cost contracts. Hypothesis 2 was tested to see if the overruns are the same. The null hypothesis, that there was no difference between cost overruns in fixed-price contracts and cost contracts, could not be rejected.

3. Aircraft Program Cost Variances

The mean cost variance of aircraft programs is the same as other types of programs. This indicates that the cost overruns in an aircraft program will be no higher than any other type of program. Hypothesis 3, was tested for differences in the mean overruns of aircraft programs and other types of programs. The null hypothesis could not be rejected, no significant difference exists. The median overruns of the sample examined were 6.13 percent for aircraft and 6.09 percent for other types of programs.

4. Budget Adjustments for Fixed-Price and Cost-Type Contracts

The required budget adjustments for fixed-price and cost-type contracts are the same. The budget adjustment is the amount, measured by percentage, required to adjust the initially specified budget to the ending budget. In other words, it is the amount of additional money the program manager needs to finish the program. The budget adjustment required to finish the A-12 Program would have been between a 77 and 93 percent increase. The mean budget adjustment for fixed-price contracts is 44 percent and the mean budget adjustment for cost-type contracts is 57 percent. Hypothesis 4 was tested to see if there are differences between the Contract Budget Base adjustments for fixed-price contracts and the CBB adjustments for cost-type contracts.

A visual inspection of the data would indicate a difference, but the Mann-Whitney test showed no statistical difference. This can be accounted for by the dispersion of the data. Prior to conducting the test the data was normalized by dividing each data point by its standard deviation. The null hypothesis, that there are no differences, could not be rejected.

5. Budget Adjustments for Aircraft Programs

Aircraft programs require about the same amount of budget adjustment as other types of programs. The mean budget adjustment for aircraft programs was higher than other types of programs. The dispersion of the values was much greater for aircraft programs than for other types of programs, and the data were normalized prior to testing. Hypothesis 5 was tested to determine if aircraft programs experience greater mean CBB adjustments than other programs. The null hypothesis could not be rejected. There is no statistical difference in the mean budget adjustments of aircraft programs and the sample.

6. Mean Values Versus Median Values

Mean values overstate cost overruns. To compare a program's overruns with other programs, the median cost overrun should be used. The mean is a good measure of central tendency for data modeled by the Normal distribution. Cost overruns are modeled by the Beta distribution. The use of the median is a more accurate measure of central tendency for skewed data. As shown in Figure 3, in Chapter II, the distribution of cost overruns is skewed to the left. The use of mean values can be misleading. For example, the mean cost variance of fixed-price contracts and cost-type contracts is -21.02 percent and -14.76 percent respectively. At first glance the conclusion could be drawn that fixed-price contracts are significantly different from cost-type contracts.

The median values for the cost variances of fixed-price and cost-type contracts are -10.2 percent and -6.05 percent respectively. The median values show less difference by contract type. The test of the hypothesis found no statistical difference in cost variances based on contract type.

7. Cost Variances of EMD Contracts

The results of this research agree with prior research, cost overruns do not get better with time. Programs less than 10 percent complete have a positive cost variance (cost underrun). From 11 percent complete on programs tend to experience cost overruns. From 11 to 80 percent complete the cost overrun increases with program length. The largest cost overrun for the sample, was from 71 to 80 percent complete and was negative 14.52 percent. The mean value of the cost variance of the sample was negative 13.37 percent while the median value was negative 6.09 percent. Very few contracts were found to have positive cost variances at any point in the program. A summary of the findings on cost variances is provided in Table 11, Chapter IV, and Table 20 in Chapter V.

The observations of Abba and Christle and the empirical findings of Heise were confirmed in that the cost variances tended to worsen as the program progressed. This is shown in Table 11, in Chapter IV.

8. Causes of Cost Growth

The cause of the A-12's cost overruns are difficult to determine. It was not the intent of this thesis to provide the answer to why the A-12 had exceptional overruns. Based on the data examined, it appears that the Program encountered significantly greater technical challenges than were anticipated, which delayed first flight and increased cost.

The contracts examined in this research all showed variances from the baseline. The majority of these contracts experienced cost overruns throughout the program. The Rand report [Ref. 10] found no single cause for the cost growth of weapon system programs. The report found a correlation between the size of the program and the length of the program and cost growth. The smaller the program, the greater the variance and the longer the program is carried out, the greater the variance.

A 1992 GAO report summarizes the problem of determining the cause of cost growth:

> The weapon system problems we have reported in the past 2 years mirror those we reported in the 1970s and the 1980s. This does not imply that the history of weapon acquisitions amounts to a string of bad programs. The point is that, despite conscious attempts to improve the acquisition process, weapons still cost more, take longer to field, often encounter performance problems, and, in many instances are difficult to produce or support. The persistence of these problems reflects the fact that the design, development, and production of major weapon systems are extremely complex technical processes....In short, it takes a myriad of things to go right for a program to be successful, but only a few things to go wrong to cause major problems. [Ref. 27: p. 15]

C. RECOMMENDATIONS

1. The A-12

The Government's decision to terminate the fixed-price contract of the A-12 is justified, based on an examination of the data used in this research, The Government should continue to pursue the case in court and demand reimbursement for the unliquidated progress payments.

2. Cost Estimating

The findings of this research indicate that estimates at completion in EMD contracts are too optimistic. As shown in Table 7, the mean adjustment to the CBB is 54 percent. Only two of the 58 contracts showed downward revisions in the CBB. More emphasis should be placed on developing realistic estimates of the cost of the contract. A cost underrun in the early stages of a program is a poor indicator of future cost performance. Fully defining the scope of work before the start of EMD may help alleviate the problem. A longer Demonstration and Validation phase may be warranted in programs with substantial technical risk.

3. Fixed-Price Contracts for EMD

The belief that fixed-price contracts place the majority of the cost risk on the contractor is not supported by the data for EMD contracts. No statistical difference was shown in the median values for cost-type contracts and fixed-price contracts. While fixed-price contracts showed more extreme points than cost-type contracts, this may have been due to the Government's reluctance to adjust the price of the fixed-price type contracts. As shown in Table 10 the Air Force has used a fixed-price type contract in the majority of EMD contracts that were examined.

The decision to use a cost-type contract will not have any impact on the cost variance of the contract. The mean budget adjustment for fixed-price contracts was 44 percent, the median value was 54 percent, while the mean budget adjustment for cost-type contracts was 57 percent and the median value was 45 percent. By examining the means for budget adjustments the conclusion could be drawn that the use of a fixed-price contract would require a smaller budget adjustment. The use of median values would show that the use of a fixed-price contract would require a greater budget adjustment. The mean values can be skewed by outliers, extreme values by very few programs.

D. AREAS FOR FURTHER RESEARCH

1. The Rayleigh Distribution Model

The Rayleigh model shows promise as a cost estimating tool. Further research into optimizing this model for more narrowly defined programs should be examined. Adjustment of the parameters of the model resulted in greater accuracy. This research used only ten values to optimize the parameters for aircraft contracts. By using more values to optimize the parameters an even more refined model could be achieved.

The Rayleigh model proved to be a better estimator of costs at completion than the CPI techniques given an unstable baseline. In programs where the baseline is relatively stable the CPI technique is both easy to use and accurate. The advantage that the Rayleigh technique provides is the ability to provide estimates independent of the baseline.

It was not the intent of this research to prove the value of the Rayleigh model. The model was selected based on its ability to provide EACs independent of current estimates of final costs. Other techniques exist for estimating costs that were also not examined.

2. Fixed-Price Contracts

This research indicates that the use of fixed-price contracts in developmental work is not inherently bad. All contracts examined had adjustments made to the CBB regardless of contract type. Additional work could examine in more detail the differences in cost variances between cost-type contracts and fixed-price type contracts.

APPENDIX A. CONTRACT DATABASE

This appendix contains the contracts used in the research. The agreement with OUSD (A&T) requires that the name of the contract and the contractor not be disclosed. The contracts are listed by number. The corresponding list of contracts can be released with the permission of the OUSD (A&T). The list of contracts used in this research is maintained by Dr. David V. Lamm, Systems Management Department, Naval Postgraduate School.

ABBREVIATIONS USED

1. **ACWP**. The reported actual cost of work performed drawn from the database.13.

2. **ALLOC BUDGET**. Actual budget committed to the program.

3. **BCWP**. The reported budgeted cost of work performed drawn from the database.

4. **CBB**. Contract Budget Base.

5. **COMPL PT**. Percentage completion point. As measured by BCWP/ALLOC BUDGET.

6. **CP**. Cost Plus.

7. **CPAF**. Cost-Plus-Award-Fee.

8. **CPIF**. Cost-Plus-Incentive-Fee.

9. **CV**. Cost Variance. Percentage cost variance determined by (BCWP-ACWP)/BCWP.

10. **FP**. Firm-Fixed-Price

11. **FPIF**. Fixed-Price-Incentive-Firm.

12. **FSD**. Full-Scale Development. Equivalent to Engineering and Manufacturing Development (EMD). Drawn from the description in the DAES database. "DEV" as used in the DAES database is equivalent to EMD.

13. **K**. Contract.

14. **K TYPE**. Contract type.

15. **SYSTEM**. The type of system the contract was for. General categories were established.

K #:	SERVICE:	SYSTEM:	PHASE:		K TYPE:	
1	AF	MISSILE	FSD	ALLOC	FPIF	
	BCWP	ACWP	CBB	BUDGET	COMPL PT	CV
	455.3	663.7	514.2	514.2	88.55%	-45.77%
	460.3	677.7	530.3	530.3	86.80%	-47.23%
	465.8	688.3	539.3	539.3	86.37%	-47.77%
	476.5	707.1	562.1	562.1	84.77%	-48.39%
	495.5	718.3	560.4	560.4	88.42%	-44.96%
	724.6	726.3	606.3	833	86.99%	-0.23%
	747.5	748.2	595.4	822.1	90.93%	-0.09%
	760.4	759.9	596.9	823.6	92.33%	0.07%
	766	771.9	591.8	814.1	94.09%	-0.77%

K #:	SERVICE:	SYSTEM:	PHASE:		K TYPE:	
2	ARMY	ELECTR	DEV		CPAF	
				ALLOC		
	BCWP	ACWP	CBB	BUDGET	COMPL PT	CV
	11.5	11.8	54.5	54.5	21.10%	-2.61%
	16.1	16.5	61.1	61.1	26.35%	-2.48%
	21.6	22.2	67.9	67.9	31.81%	-2.78%
	28.7	30.7	68.6	68.6	41.84%	-6.97%
	35.6	39.1	68.7	68.7	51.82%	-9.83%
	42.3	46.9	65.5	65.5	64.58%	-10.87%
	49	52.3	66	66	74.24%	-6.73%
	55.7	60.7	66.4	66.4	83.89%	-8.98%
	60.2	68.1	68.5	68.5	87.88%	-13.12%
	63.3	73.7	69.4	69.4	91.21%	-16.43%
	66.3	78.5	71.5	71.5	92.73%	-18.40%
	68.7	84.8	73.4	73.4	93.60%	-23.44%
	70.8	90	75	75	94.40%	-27.12%
	72	94.4	75	75	96.00%	-31.11%
	71	96.1	73	73	97.26%	-35.35%
	71.7	98.9	72.9	72.9	98.35%	-37.94%

K #:	SERVICE:	SYSTEM:	PHASE:		K TYPE:	
3	AF	MISSILE	FSD		FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	10.7	10.9	376.1	376.1	2.84%	-1.87%
	37.9	38.9	386.6	386.6	9.80%	-2.64%
	56.9	58.4	386.6	386.6	14.72%	-2.64%
	85.1	89.4	386.7	386.7	22.01%	-5.05%
	97.1	101.7	395.1	395.1	24.58%	-4.74%
	118.9	133.1	395.1	395.1	30.09%	-11.94%
	161.2	193.6	395.1	395.1	40.80%	-20.10%
	202.4	257.4	395.1	395.1	51.23%	-27.17%
	220.5	285.4	395.1	395.1	55.81%	-29.43%
	246.9	335.4	395.3	395.3	62.46%	-35.84%
	273.6	388.7	396.4	396.4	69.02%	-42.07%
	303.7	459.7	394.6	394.6	76.96%	-51.37%
	307.7	473.8	394.6	394.6	77.98%	-53.98%
	319.4	517	394	394	81.07%	-61.87%
	336.6	589	394	394	85.43%	-74.99%
	355.7	644.6	394	394	90.28%	-81.22%
	344	725.1	394	807	42.63%	-110.78%
	351.2	726.2	392.7	807	43.52%	-106.78%
	354.5	731.9	392.7	807	43.93%	-106.46%
	359.6	739.5	393.6	807	44.56%	-105.65%
	362.5	746.8	393.6	807	44.92%	-106.01%
	365.6	753.5	393.6	807	45.30%	-106.10%
	369	761	393.6	807	45.72%	-106.23%
	371.3	767.2	393.6	807	46.01%	-106.63%
	372.6	770.8	393.6	807	46.17%	-106.87%
	374.3	781.3	393.6	807	46.38%	-108.74%

K #: 4	SERVICE: AF	SYSTEM: MISSILE	PHASE: FSD		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	2.4	2.4	15.1	15.1	15.89%	0.00%
	3	3	15.1	15.1	19.87%	0.00%
	3.9	4	15.1	15.1	25.83%	-2.56%
	5.1	5.1	15.1	15.1	33.77%	0.00%
	7.2	7.2	15.1	15.1	47.68%	0.00%
	8.5	8.4	15.1	15.1	56.29%	1.18%
	9.5	9.7	15.1	15.1	62.91%	-2.11%
	11.9	12.5	15.1	15.1	78.81%	-5.04%
	12.8	14.4	23.5	23.5	54.47%	-12.50%
	14.2	15.4	23.5	23.5	60.43%	-8.45%
	15.8	16.4	23.5	23.5	67.23%	-3.80%
	16.2	16.7	23.5	23.5	68.94%	-3.09%
	16.6	16.9	23.5	23.5	70.64%	-1.81%
	17	17.2	23.5	23.5	72.34%	-1.18%
	17.4	17.6	23.5	23.5	74.04%	-1.15%
	18	18.1	23.5	23.5	76.60%	-0.56%
	18.4	18.4	23.5	23.5	78.30%	0.00%
	19.2	19.7	23.5	23.5	81.70%	-2.60%
	20.5	21.5	23.5	23.5	87.23%	-4.88%

K #: 5	SERVICE: NAVY	SYSTEM: ELECTRONICS	PHASE: FSD		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	17.4	16.6	137.5	137.5	12.65%	4.60%
	29.8	30.2	137.6	137.6	21.66%	-1.34%
	59.8	61.4	674.3	674.3	8.87%	-2.68%
	88.5	91.3	670.6	670.6	13.20%	-3.16%
	107.6	111.5	674.3	674.3	15.96%	-3.62%
	218.7	230.5	674.3	674.3	32.43%	-5.40%
	244.4	272	674.3	674.3	36.24%	-11.29%
	277.5	312.4	674.3	674.3	41.15%	-12.58%
	347.7	405	990.5	990.5	35.10%	-16.48%
	372.7	437	1043.7	1043.7	35.71%	-17.25%
	421.4	498.5	1043.7	1043.7	40.38%	-18.30%
	581.2	589	1405.3	1405.3	41.36%	-1.34%
	623.4	627.4	998	998	62.46%	-0.64%
	695.5	709.6	998	998	69.69%	-2.03%
	734.3	747.9	998	998	73.58%	-1.85%
	777.1	794.1	998	998	77.87%	-2.19%
	791.2	813.7	998	998	79.28%	-2.84%
	820.6	854.1	998	998	82.22%	-4.08%
	838.9	883.5	998	998	84.06%	-5.32%
	849.8	899	998	998	85.15%	-5.79%
	883	934.9	998	998	88.48%	-5.88%
	903	944.8	998	998	90.48%	-4.63%
	906.8	954.2	998	998	90.86%	-5.23%

K #: 6	SERVICE: ARMY	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	0.10	2.6	293.9	293.9	0.03%	-25.00
	0.20	7.4	293.9	293.9	0.07%	NA
	18.9	23.1	293.9	293.9	6.43%	-22.22%
	30	39.5	293.9	293.9	10.21%	-31.67%
	56.3	62.7	292.9	292.9	19.22%	-11.37%
	87.9	90.4	348.5	348.5	25.22%	-2.84%
	112.5	118.4	366.1	366.1	30.73%	-5.24%
	136.7	141.5	368	368	37.15%	-3.51%
	160.9	169.2	369.6	369.6	43.53%	-5.16%
	185.8	196.2	369.8	369.8	50.24%	-5.60%
	209.6	225.6	374	374	56.04%	-7.63%
	233.3	255.4	374.5	374.5	62.30%	-9.47%
	259	288.4	374	374	69.25%	-11.35%
	280.3	324	382.9	382.9	73.20%	-15.59%
	295.7	347.4	383.3	383.3	77.15%	-17.48%
	324.9	384.2	379	379	85.73%	-18.25%
	311.6	404.2	382.1	382.1	81.55%	-29.72%
	340.3	435.3	386.1	386.1	88.14%	-27.92%
	350.1	458.4	422.7	422.7	82.82%	-30.93%
	370.4	489.5	422.7	422.7	87.63%	-32.15%
	396.4	527.8	423.4	423.4	93.62%	-33.15%
	414.2	545.6	428.2	428.2	96.73%	-31.72%
	418.9	554.1	429.5	429.5	97.53%	-32.28%

K #: 7	SERVICE: ARMY	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	0.20	0.1	27.7	27.7	0.72%	0.50
	1.10	1	27.7	27.7	3.97%	9.09%
	3.7	3.6	27.7	27.7	13.36%	2.70%
	7.1	6.7	27.7	27.7	25.63%	5.63%
	9.7	9.9	27.7	27.7	35.02%	-2.06%
	12.3	12.3	27.7	27.7	44.40%	0.00%
	13.3	13.4	27.7	27.7	48.01%	-0.75%
	15.1	15	27.7	27.7	54.51%	0.66%
	15.9	15.9	37.4	37.4	42.51%	0.00%
	16.8	17	37.4	37.4	44.92%	-1.19%
	17.9	18.1	37.4	37.4	47.86%	-1.12%
	19.2	19.6	37.4	37.4	51.34%	-2.08%
	20.6	21.2	37.4	37.4	55.08%	-2.91%
	22.4	23	37.4	37.4	59.89%	-2.68%
	24.6	24.7	37.4	37.4	65.78%	-0.41%
	26.2	26.5	37.4	37.4	70.05%	-1.15%
	26.7	27.9	37.5	37.5	71.20%	-4.49%
	29.8	30.5	37.6	37.6	79.26%	-2.35%
	32.6	33.1	37.6	37.6	86.70%	-1.53%
	34.4	34.6	37.6	37.6	91.49%	-0.58%
	36.2	36.6	37.6	37.6	96.28%	-1.10%
	38	38.2	37.6	37.6	101.06%	-0.53%

K #: 8	SERVICE: NAVY	SYSTEM: AIRCRAFT	PHASE: FSD		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	362.10	369.1	582.3	582.3	62.18%	-0.02
	407.30	412	586.5	586.5	69.45%	-1.15%
	419.7	430.3	582.8	582.8	72.01%	-2.53%
	440.2	453	582.8	582.8	75.53%	-2.91%
	453.9	466.1	582.8	582.8	77.88%	-2.69%
	480.4	491.9	582.8	582.8	82.43%	-2.39%
	489.9	502.6	583.7	583.7	83.93%	-2.59%
	505.8	518.6	584	584	86.61%	-2.53%
	522	540.3	584	584	89.38%	-3.51%
	527.1	528.4	584	584	90.26%	-0.25%
	541.5	554.3	586	586	92.41%	-2.36%

K #: 9	SERVICE: NAVY	SYSTEM: ELECTRONICS	PHASE: DEV		K TYPE: CPFF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	533.10	536.6	846.4	846.4	62.98%	-0.01
	649.10	650.8	887	887	73.18%	-0.26%
	676	673.9	869.9	869.9	77.71%	0.31%
	711.3	709.5	873.5	873.5	81.43%	0.25%
	738.9	739.3	886	886	83.40%	-0.05%
	762.7	765.3	891.2	891.2	85.58%	-0.34%
	775.9	780.5	895.4	895.4	86.65%	-0.59%
	802.7	802.3	942.7	942.7	85.15%	0.05%
	822.2	823.6	941.6	941.6	87.32%	-0.17%
	840.4	839.6	942.6	942.6	89.16%	0.10%
	851.1	849.3	944.6	944.6	90.10%	0.21%
	875.5	872.4	920.6	920.6	95.10%	0.35%

K #: 10	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	1172.80	1175.7	1516.9	1516.9	77.32%	-0.00
	1227.80	1232.7	1518.7	1518.7	80.85%	-0.40%
	1290.1	1293.7	1809.7	1809.7	71.29%	-0.28%
	1356.3	1353.1	1846.3	1846.3	73.46%	0.24%
	1442.5	1437.3	1898.8	1898.8	75.97%	0.36%
	1466.1	1461.4	1915.8	1915.8	76.53%	0.32%
	1523.2	1540.4	2010.6	2035.8	74.82%	-1.13%
	1598.4	1626.7	2034.1	2059.3	77.62%	-1.77%
	1667.1	1713.2	2049.1	2074.3	80.37%	-2.77%
	1738.8	1800.3	2069.5	2094.7	83.01%	-3.54%
	1769.4	1834.2	2118	2143.2	82.56%	-3.66%
	1889.6	1974.3	2119.6	2146	88.05%	-4.48%
	1973	2032.6	2156.8	2223.1	88.75%	-3.02%
	2028.1	2084.1	2178.4	2244.6	90.35%	-2.76%
	2063.7	2114.2	2173.1	2239.3	92.16%	-2.45%
	2115.3	2139.4	2182.8	2226.2	95.02%	-1.14%

K #: 11	SERVICE: NAVY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	36.50	38.2	83.7	83.7	43.61%	-0.05
	48.50	52.8	120.3	120.3	40.32%	-8.87%
	57	62	119.9	119.9	47.54%	-8.77%
	81.1	85.5	124.8	124.8	64.98%	-5.43%
	65.5	69.2	102.1	102.1	64.15%	-5.65%
	85.3	91.5	111	111	76.85%	-7.27%
	86	96.5	113.1	113.1	76.04%	-12.21%
	90.1	99.9	111.3	111.3	80.95%	-10.88%
	98.9	108.6	116.1	116.1	85.19%	-9.81%
	100.3	111.5	114.7	114.7	87.45%	-11.17%
	102.5	112.4	115.4	115.4	88.82%	-9.66%
	105.6	116.4	115.8	115.8	91.19%	-10.23%

K #: 12	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: FSD		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	68.10	68.4	163.5	163.5	41.65%	-0.00
	87.10	87.2	163.5	163.5	53.27%	-0.11%
	97.8	99.1	163.5	163.5	59.82%	-1.33%
	103.1	106.1	163.5	163.5	63.06%	-2.91%
	107.7	111.8	167.5	167.5	64.30%	-3.81%
	112.9	116.4	167.5	167.5	67.40%	-3.10%
	118.4	123	167.5	167.5	70.69%	-3.89%
	123.2	127.3	168.7	168.7	73.03%	-3.33%
	127.9	131.7	168.7	168.7	75.82%	-2.97%
	130.9	135.3	168.7	168.7	77.59%	-3.36%
	133.3	136.8	169.8	169.8	78.50%	-2.63%
	136.8	138.4	169.6	169.6	80.66%	-1.17%
	141.8	143.9	169.7	169.7	83.56%	-1.48%
	147.7	149	169.7	169.7	87.04%	-0.88%
	151.1	151.9	170.1	170.1	88.83%	-0.53%
	153.9	154.3	170.1	170.1	90.48%	-0.26%
	153	155.3	170.1	170.1	89.95%	-1.50%

K #: 13	SERVICE: NAVY	SYSTEM: ELECTRONICS	PHASE: FSD		K TYPE: FP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	22.90	23	878.2	878.2	2.61%	-0.00
	50.40	49.3	923.3	923.3	5.46%	2.18%
	80.3	78	886	886	9.06%	2.86%
	112.4	108.3	886	886	12.69%	3.65%
	141.1	145.2	886.1	886.1	15.92%	-2.91%
	181.2	189.3	886.1	886.1	20.45%	-4.47%
	222.5	239.3	886.1	886.1	25.11%	-7.55%
	264.8	293.2	886.1	886.1	29.88%	-10.73%
	305.7	350.6	886.1	886.1	34.50%	-14.69%
	359.5	412.6	896.8	896.8	40.09%	-14.77%
	413	471.3	891.1	891.1	46.35%	-14.12%
	472	535.3	902.2	902.2	52.32%	-13.41%

K #: 14	SERVICE: ARMY	SYSTEM: AIRCRAFT	PHASE: FSD		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	1.10	1.2	43	43	2.56%	-0.09
	4.70	5.1	43.3	43.3	10.85%	-8.51%
	7.9	10.1	43.3	43.3	18.24%	-27.85%
	13.2	16.5	43.3	43.3	30.48%	-25.00%
	19.9	24.3	43.3	43.3	45.96%	-22.11%
	25.9	32.9	43.4	43.4	59.68%	-27.03%
	31.1	40.3	43.4	43.4	71.66%	-29.58%
	32.6	44.5	44.2	44.2	73.76%	-36.50%
	34	47.3	44.2	44.2	76.92%	-39.12%
	35.9	50.9	45.1	45.1	79.60%	-41.78%
	40.8	55.6	45.1	45.1	90.47%	-36.27%
	41.9	58	45.2	45.2	92.70%	-38.42%
	42.7	60.4	45.2	45.2	94.47%	-41.45%

K #: 15	SERVICE: ARMY	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	0.40	0.3	34.7	34.7	1.15%	0.25
	1.20	1.1	34.7	34.7	3.46%	8.33%
	13	12.8	34.7	34.7	37.46%	1.54%
	17.5	17.4	34.7	34.7	50.43%	0.57%
	22.2	22.1	34.7	34.7	63.98%	0.45%
	26.6	26.3	40.2	40.2	66.17%	1.13%
	29.8	29.9	40.2	40.2	74.13%	-0.34%
	32.9	33	40.2	40.2	81.84%	-0.30%
	35.7	34.8	40.5	40.5	88.15%	2.52%
	37.4	36.4	40.5	40.5	92.35%	2.67%
	38.7	37.8	40.8	40.8	94.85%	2.33%
	38.9	38.4	40.8	40.8	95.34%	1.29%
	39	38.6	40.8	40.8	95.59%	1.03%
	39.2	39	40.8	40.8	96.08%	0.51%
	39.6	39.5	40.8	40.8	97.06%	0.25%
	40.2	40.1	40.8	40.8	98.53%	0.25%
	40.6	40.6	41	41	99.02%	0.00%

K #: 16	SERVICE: ARMY	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	3.10	3.2	58.6	58.6	5.29%	-0.03
	10.60	11.4	58.9	58.9	18.00%	-7.55%
	16.8	20.3	58.9	58.9	28.52%	-20.83%
	24.5	29	58.9	58.9	41.60%	-18.37%
	32.6	38.1	58.9	58.9	55.35%	-16.87%
	39.2	46.7	59.1	59.1	66.33%	-19.13%
	44.7	55.6	59.2	59.2	75.51%	-24.38%
	46.7	60.1	60.4	60.4	77.32%	-28.69%
	48.2	63.1	60.4	60.4	79.80%	-30.91%
	50.6	66.9	61.3	61.3	82.54%	-32.21%
	56.8	74.2	61.4	61.4	92.51%	-30.63%

K #: 17	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: FSD		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	53.40	52.7	2523.1	2523.1	2.12%	0.01
	79.70	79.5	2523.1	2523.1	3.16%	0.25%
	128.7	125.5	2523.1	2523.1	5.10%	2.49%
	163.9	160.6	2523.1	2523.1	6.50%	2.01%
	235.8	229.8	3006.7	3006.7	7.84%	2.54%
	274.3	266	3006.7	3006.7	9.12%	3.03%
	433.2	427.5	3656.7	3656.7	11.85%	1.32%
	551.2	551.8	3678.3	3678.3	14.99%	-0.11%
	719.2	737.2	3678.3	3678.3	19.55%	-2.50%
	1272.3	1361.8	3778.9	3778.9	33.67%	-7.03%
	1580.9	1729.3	3778.9	3778.9	41.83%	-9.39%
	2077.8	2415.1	3778.9	3778.9	54.98%	-16.23%
	2584.1	3260.8	3775.4	3775.4	68.45%	-26.19%
	2933	4371.1	3775.4	3775.4	77.69%	-49.03%
	3065.7	4443.7	3774.9	3774.9	81.21%	-44.95%
	3382.7	4923.4	3779	3779	89.51%	-45.55%
	3511.8	5100.3	3783	3783	92.83%	-45.23%
	3597.3	5234	3782.8	3782.8	95.10%	-45.50%
	3660.7	5346.2	3789.6	3789.6	96.60%	-46.04%
	3695.8	5417.4	3789.5	3789.5	97.53%	-46.58%
	3725.8	5490	3789.5	3789.5	98.32%	-47.35%
	3771.3	5650	3820.6	3820.6	98.71%	-49.82%
	5153.3	8096.9	5551.3	5551.3	92.83%	-57.12%

K #: 18	SERVICE: NAVY	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	32.70	36.6	71.9	71.9	45.48%	-0.12
	34.30	42.3	77.8	77.8	44.09%	-23.32%
	37.6	44.4	78.4	78.4	47.96%	-18.09%
	53.2	60.7	71.8	71.8	74.09%	-14.10%
	55.8	64.4	74	74	75.41%	-15.41%
	58.1	68.1	76	76	76.45%	-17.21%
	63.7	71.6	79.2	79.2	80.43%	-12.40%
	68	76.7	80.2	80.2	84.79%	-12.79%
	71.5	80.4	80.7	80.7	88.60%	-12.45%
	73.7	84	82.7	82.7	89.12%	-13.98%
	75.8	86.5	83.2	83.2	91.11%	-14.12%
	76.4	86.1	84	84	90.95%	-12.70%
	77.4	87.6	84.1	84.1	92.03%	-13.18%
	77.5	87.9	84.2	84.2	92.04%	-13.42%

K #: 19	SERVICE: ARMY	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	0.10	7.4	0	0		-73.00
	45.40	43.2	1780.8	1780.8	2.55%	4.85%
	89.8	93.9	1781.3	1781.3	5.04%	-4.57%
	158.4	163.5	1781.3	1781.3	8.89%	-3.22%
	252.6	270.6	1782.5	1782.5	14.17%	-7.13%
	362	373.7	1786.6	1786.6	20.26%	-3.23%
	462.5	473.6	1938.6	1938.6	23.86%	-2.40%
	510.1	520	1938.6	1938.6	26.31%	-1.94%
	623.9	633.8	1885.8	1885.8	33.08%	-1.59%
	656.2	672.4	1886.2	1886.2	34.79%	-2.47%
	788.4	806.8	1886.7	1886.7	41.79%	-2.33%
	881	904.2	1895	1895	46.49%	-2.63%
	970.8	997.6	1911.2	1911.2	50.80%	-2.76%
	1060.9	1093.2	1888.4	1888.4	56.18%	-3.04%
	1133.2	1166.5	1925.7	1925.7	58.85%	-2.94%
	1210.3	1243.5	1964.5	1964.5	61.61%	-2.74%
	1295.1	1330.1	1984	1984	65.28%	-2.70%
	1352.9	1389.8	1985.2	1985.2	68.15%	-2.73%

K #: 20	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	530.40	543.8	763.9	763.9	69.43%	-0.03
	541.40	556.5	764.7	764.7	70.80%	-2.79%
	598.6	619.8	765.2	765.2	78.23%	-3.54%
	633.5	660.3	774.2	774.2	81.83%	-4.23%
	662.2	697	782.5	782.5	84.63%	-5.26%
	690	732.1	790.2	790.2	87.32%	-6.10%
	704.2	753.3	793.9	793.9	88.70%	-6.97%
	724.4	777.1	795.3	795.3	91.09%	-7.27%
	741.5	800.4	803.1	803.1	92.33%	-7.94%
	764.3	824.6	824.1	824.1	92.74%	-7.89%
	784	844.4	895.2	895.2	87.58%	-7.70%
	796.5	856.4	889.1	889.1	89.58%	-7.52%
	813.8	884.4	929.4	929.4	87.56%	-8.68%
	826.3	899.2	940	940	87.90%	-8.82%
	833.6	907.3	938.3	938.3	88.84%	-8.84%
	849.5	922.7	939.6	939.6	90.41%	-8.62%

K #: 21	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	2.30	2.7	66.4	66.4	3.46%	-0.17
	6.30	6.6	65.9	65.9	9.56%	-4.76%
	8.4	9.5	83.3	83.3	10.08%	-13.10%
	13.8	16.3	90.4	90.4	15.27%	-18.12%
	28.9	28.8	121.8	121.8	23.73%	0.35%
	48.3	48.3	196.4	196.4	24.59%	0.00%
	56.3	55.7	216.8	216.8	25.97%	1.07%
	71.2	70.4	297.5	297.5	23.93%	1.12%
	81.7	80.4	297	297	27.51%	1.59%
	93.1	91.8	197.6	197.6	47.12%	1.40%
	101.9	100.3	197.5	197.5	51.59%	1.57%
	115.5	114.4	199.1	199.1	58.01%	0.95%
	132.1	131.5	202.5	202.5	65.23%	0.45%
	147.7	147.8	205.2	205.2	71.98%	-0.07%
	159.8	160.6	203.2	203.2	78.64%	-0.50%
	170.9	173.1	202.8	202.8	84.27%	-1.29%
	179.8	184.5	201.9	201.9	89.05%	-2.61%
	185.5	192.4	215.7	215.7	86.00%	-3.72%
	190.1	200.4	217.6	217.6	87.36%	-5.42%
	193.9	205.9	218.4	218.4	88.78%	-6.19%
	197.2	203.7	218.5	218.5	90.25%	-3.30%
	203.3	215.6	220.9	220.9	92.03%	-6.05%

K #: 22	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: FSD		K TYPE: CPAF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	189.40	187.1	9241.8	9241.8	2.05%	0.01
	395.10	391.8	9244	9244	4.27%	0.84%
	641.5	647.5	9248.9	9248.9	6.94%	-0.94%
	725.6	732	9248.9	9248.9	7.85%	-0.88%
	822.1	840.6	9248.7	9248.7	8.89%	-2.25%
	1188.9	1208.3	10275.7	10275.7	11.57%	-1.63%
	1503.2	1539.1	10286.8	10286.8	14.61%	-2.39%
	1839.2	1857.1	10302.3	10302.3	17.85%	-0.97%
	2192.5	2215	10313.4	10313.4	21.26%	-1.03%
	2525	2548.8	10415	10415	24.24%	-0.94%
	2873.8	2944.1	10415.8	10415.8	27.59%	-2.45%
	3238.7	3308.9	10525.3	10525.3	30.77%	-2.17%
	3599	3713.8	10524.5	10524.5	34.20%	-3.19%
	3949.1	4084.5	10578.6	10578.6	37.33%	-3.43%
	4319.2	4515.2	10586.8	10586.8	40.80%	-4.54%

K #: 23	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: FSD		K TYPE: CPAF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	111.20	108.8	1322.2	1322.2	8.41%	0.02
	178.80	183.6	1322.2	1322.2	13.52%	-2.68%
	260.6	265.5	1322.2	1322.2	19.71%	-1.88%
	311.5	319.5	1322.2	1322.2	23.56%	-2.57%
	405.2	425.9	1437.4	1437.4	28.19%	-5.11%
	474	497.8	1461.6	1461.6	32.43%	-5.02%
	542.5	559.4	1463.9	1463.9	37.06%	-3.12%
	595	613.9	1462.6	1462.6	40.68%	-3.18%
	640.2	664.8	1470.5	1470.5	43.54%	-3.84%
	695.7	724.1	1655.1	1655.1	42.03%	-4.08%
	755.6	782.9	1752.5	1752.5	43.12%	-3.61%
	819.1	845.6	1761.5	1761.5	46.50%	-3.24%
	886.4	908.4	1761.7	1761.7	50.32%	-2.48%
	956	986.7	1761.8	1761.8	54.26%	-3.21%

K #: 24	SERVICE: NAVY	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	4.10	4	330.6	330.6	1.24%	0.02
	9.60	9.5	330.6	330.6	2.90%	1.04%
	22.9	23.3	330.6	330.6	6.93%	-1.75%
	38.4	38.5	309.5	309.5	12.41%	-0.26%
	52.2	52.6	309.5	309.5	16.87%	-0.77%
	74.5	74.7	309.5	309.5	24.07%	-0.27%
	94.9	97.3	309.5	309.5	30.66%	-2.53%
	110.9	111.3	309.5	309.5	35.83%	-0.36%
	126.5	127.7	309.5	309.5	40.87%	-0.95%
	145.4	144.9	309.9	309.9	46.92%	0.34%
	164.8	167.9	309.9	309.9	53.18%	-1.88%
	188.9	187.9	309.9	309.9	60.96%	0.53%
	209.5	211.6	309.9	309.9	67.60%	-1.00%
	229	230.3	309.9	309.9	73.89%	-0.57%
	257.5	261.7	309.9	309.9	83.09%	-1.63%
	275.6	279.1	309.9	309.9	88.93%	-1.27%
	281.8	288.6	310.4	316.2	89.12%	-2.41%
	292.1	296.5	311.5	315.4	92.61%	-1.51%
	299	303.4	311.5	315.4	94.80%	-1.47%
	304.7	310.9	311.5	314.8	96.79%	-2.03%
	305.5	315	317.3	320.7	95.26%	-3.11%
	308.8	321.7	317.3	320.7	96.29%	-4.18%
	309.1	323.7	317.3	320.7	96.38%	-4.72%
	310.2	325.9	317.3	320.7	96.73%	-5.06%
	311.2	329.9	317.3	320.7	97.04%	-6.01%

K #: 25	SERVICE: NAVY	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	21.80	20.6	1020.2	1020.2	2.14%	0.06
	51.90	49.5	1022.2	1022.2	5.08%	4.62%
	95.3	97	1047.2	1047.2	9.10%	-1.78%
	117.2	123.4	1048.2	1048.2	11.18%	-5.29%
	168.9	185.9	1055.1	1055.1	16.01%	-10.07%
	236.8	260.3	1079.1	1079.1	21.94%	-9.92%
	372.2	412.2	1092.2	1092.2	34.08%	-10.75%
	462.2	515.6	1103	1103	41.90%	-11.55%
	527.1	597.3	1105.4	1105.4	47.68%	-13.32%
	546.3	639.1	1105.4	1281.5	42.63%	-16.99%
	580.9	674.8	1109.7	1281.7	45.32%	-16.16%
	644.3	748	1115.9	1288	50.02%	-16.09%
	713.4	850.5	1148.2	1320.2	54.04%	-19.22%
	771	933.4	1152.9	1324.9	58.19%	-21.06%
	836.6	1011.3	1167.5	1339.5	62.46%	-20.88%
	876.4	1071.2	1186.5	1358.6	64.51%	-22.23%
	928.6	1150.7	1185.9	1357.9	68.39%	-23.92%
	970.4	1207.9	1185.9	1375.6	70.54%	-24.47%
	941.7	1271.1	1184	1590	59.23%	-34.98%
	961.5	1294.1	1184	1590	60.47%	-34.59%
	1049.8	1340.9	1185.5	1502.1	69.89%	-27.73%
	1044.2	1396.1	1186.8	1590	65.67%	-33.70%
	1075.1	1458.2	1186.7	1590	67.62%	-35.63%
	1077.6	1502	1189.7	1632	66.03%	-39.38%
	1085	1516.7	1189.7	1632	66.48%	-39.79%
	1098.8	1547.5	1189.7	1632	67.33%	-40.84%
	1113.8	1582.3	1189.7	1632.2	68.24%	-42.06%
	1130.7	1616.8	1189.9	1631.1	69.32%	-42.99%
	1144	1640.2	1189.9	1631.1	70.14%	-43.37%
	1165.1	1670.1	1193.7	1636	71.22%	-43.34%

K #: 26	SERVICE: NAVY	SYSTEM: AIRCRAFT	PHASE: FSD		K TYPE: CPAF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	30.70	28.7	3436.5	3436.5	0.89%	0.07
	66.80	61.5	3436.5	3436.5	1.94%	7.93%
	171.2	163.7	3290.5	3290.5	5.20%	4.38%
	267	250.9	3290.5	3290.5	8.11%	6.03%
	370.1	355.7	3292.1	3292.1	11.24%	3.89%
	509.6	509.4	3274.1	3274.1	15.56%	0.04%
	670.7	678.8	3321.7	3321.7	20.19%	-1.21%
	885.5	877.5	3333.6	3333.6	26.56%	0.90%
	970	956.9	3373.6	3373.6	28.75%	1.35%
	1052.5	1038.5	3371.2	3371.2	31.22%	1.33%
	1134.3	1116.7	3371.2	3371.2	33.65%	1.55%
	1371.7	1363.2	3372	3372	40.68%	0.62%
	1597.4	1598.5	3401.8	3401.8	46.96%	-0.07%
	1857.4	1871.7	3402	3402	54.60%	-0.77%

K #: 27	SERVICE: NAVY	SYSTEM: AIRCRAFT	PHASE: FSD		K TYPE: CPAF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	0.01	30.4	0	0	ERR	NA
	44.50	41.8	656.9	656.9	6.77%	6.07%
	113.9	111.2	656.9	656.9	17.34%	2.37%
	172.9	176	656.9	656.9	26.32%	-1.79%
	236.4	241.2	656.9	656.9	35.99%	-2.03%
	261.6	266.4	656.9	656.9	39.82%	-1.83%
	283.6	294.3	656.9	656.9	43.17%	-3.77%
	330.9	342.7	658.5	658.5	50.25%	-3.57%
	360.4	373.1	658.5	658.5	54.73%	-3.52%
	390	404.2	658.5	658.5	59.23%	-3.64%
	420.6	437.3	658.5	658.5	63.87%	-3.97%
	457.2	479.4	658.5	658.5	69.43%	-4.86%

K #: 28	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	16.10	17.8	169.9	164.6	9.78%	-10.56%
	30.80	36.6	170.7	170.7	18.04%	-18.83%
	52.6	69.6	170.8	170.8	30.80%	-32.32%
	72.1	100.8	173.8	173.8	41.48%	-39.81%
	92	123.6	174.5	230.7	39.88%	-34.35%
	99.9	136.1	174.9	231.1	43.23%	-36.24%
	124.8	179.9	178	234.2	53.29%	-44.15%
	128.8	198.5	177.9	234.2	55.00%	-54.11%
	133	209.4	178.4	234.7	56.67%	-57.44%
	112.2	234.9	179.2	371.9	30.17%	-109.36%
	118	251.2	179.2	371.9	31.73%	-112.88%
	113.3	279.5	179.1	441.9	25.64%	-146.69%
	123.5	307	179.1	441.9	27.95%	-148.58%
	130.8	326.4	178.9	441.9	29.60%	-149.54%
	141.5	357.3	179	442	32.01%	-152.51%
	151.5	385	179	442.1	34.27%	-154.13%
	161.2	410.4	179.2	442.2	36.45%	-154.59%
	168.3	429.8	179.2	442.2	38.06%	-155.38%
	176	444.2	182.3	445.4	39.52%	-152.39%
	180.4	455.7	182.4	445.5	40.49%	-152.61%
	181	458.8	182.4	445.5	40.63%	-153.48%
	191	462.2	200.8	467.4	40.86%	-141.99%
	192.9	468.7	201.2	467.9	41.23%	-142.98%

K #: 29	SERVICE: ARMY	SYSTEM: AIRCRAFT	PHASE: FSD		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	14.80	14.5	183.8	183.8	8.05%	2.03%
	48.90	49.6	183.8	183.8	26.61%	-1.43%
	93	95.4	262.6	262.6	35.42%	-2.58%
	140.4	151.5	261.5	261.5	53.69%	-7.91%
	155.5	170.2	261.4	261.4	59.49%	-9.45%
	168	185.1	263.6	263.6	63.73%	-10.18%
	181.8	201.7	328.8	328.8	55.29%	-10.95%
	193.7	215.7	326.1	326.1	59.40%	-11.36%
	218.1	245.7	329.6	329.6	66.17%	-12.65%
	246.2	274.1	347.1	347.1	70.93%	-11.33%
	289.8	319.5	359.6	359.6	80.59%	-10.25%
	336.4	366.3	400.4	400.4	84.02%	-8.89%
	371.8	394.6	415.1	415.1	89.57%	-6.13%

K #: 30	SERVICE: NAVY	SYSTEM: TORPEDO	PHASE: FSD		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	3.4	3.5	434.7	434.7	0.78%	-2.94%
	49.9	51.6	427	427	11.69%	-3.41%
	108	113.3	431.1	431.1	25.05%	-4.91%
	150.3	161.7	433.6	433.6	34.66%	-7.58%
	204.8	225.4	433.9	433.9	47.20%	-10.06%
	255.6	291.6	436.2	436.2	58.60%	-14.08%
	336	341.1	517.8	517.8	64.89%	-1.52%
	352.3	358.7	520.3	520.3	67.71%	-1.82%
	460.9	458.9	663.3	663.3	69.49%	0.43%
	527.3	528.8	666.7	666.7	79.09%	-0.28%
	584	592.9	668.6	668.6	87.35%	-1.52%
	627.8	647.5	670.3	670.3	93.66%	-3.14%
	649.3	681.1	671.5	671.5	96.69%	-4.90%
	661.6	703.1	669	669	98.89%	-6.27%

K #: 31	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	10.7	9.5	17.8	17.8	60.11%	11.21%
	17.9	15.3	43.4	43.4	41.24%	14.53%
	24.6	22.8	50.7	50.7	48.52%	7.32%
	36.2	34	89.3	89.3	40.54%	6.08%
	50.6	46.5	93.5	93.5	54.12%	8.10%
	63.3	58.1	94.4	94.4	67.06%	8.21%
	74.3	68.4	95.3	95.3	77.96%	7.94%
	83.9	78.9	95.6	95.6	87.76%	5.96%
	89.8	86.2	99.4	99.4	90.34%	4.01%
	91.8	89	99.4	99.4	92.35%	3.05%
	92.8	90.1	99.4	99.4	93.36%	2.91%
	94.1	91.3	100.4	100.4	93.73%	2.98%
	95.2	91.9	100.4	100.4	94.82%	3.47%
	96.2	93.6	101.3	101.3	94.97%	2.70%
	96.8	95.1	101.3	101.3	95.56%	1.76%
	98	96.3	101.3	101.3	96.74%	1.73%

K #: 32	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	76.6	74.1	507.4	507.4	15.10%	3.26%
	204.8	204.4	507.1	507.1	40.39%	0.20%
	409.6	411	548.2	548.2	74.72%	-0.34%
	463.6	470.6	552	552	83.99%	-1.51%
	477	485.9	551.8	551.8	86.44%	-1.87%
	507.3	517.8	570.4	570.4	88.94%	-2.07%
	541.7	554.2	954.2	954.2	56.77%	-2.31%
	603.3	614.8	955.3	955.3	63.15%	-1.91%
	671.2	696.9	956.8	956.8	70.15%	-3.83%
	739.7	756.7	1041.7	1041.7	71.01%	-2.30%
	810.4	829.6	1039.3	1039.3	77.98%	-2.37%
	884.9	906	1062.8	1062.8	83.26%	-2.38%
	961.2	991.1	1097.3	1097.3	87.60%	-3.11%
	1023.9	1066.1	1106.9	1106.9	92.50%	-4.12%
	1071.9	1127.6	1106.3	1106.3	96.89%	-5.20%

K #: 33	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	73	82.2	156.8	156.8	46.56%	-12.60%
	94.4	112.9	155.1	155.1	60.86%	-19.60%
	146.4	147.9	155.1	155.1	94.39%	-1.02%
	165.6	169.4	253.1	253.1	65.43%	-2.29%
	194.8	194.8	309.1	309.1	63.02%	0.00%
	223	223.2	309.5	309.5	72.05%	-0.09%
	248.4	260.7	309.5	309.5	80.26%	-4.95%
	273	302	309.5	309.5	88.21%	-10.62%
	279	326.4	309.5	309.5	90.15%	-16.99%
	279	338.6	347.3	347.3	80.33%	-21.36%
	279	359.5	371.4	371.4	75.12%	-28.85%
	401	401.6	426.8	426.8	93.96%	-0.15%

K #: 34	SERVICE: NAVY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	7.9	6.6	188	188	4.20%	16.46%
	18.2	15.9	188	188	9.68%	12.64%
	28.3	28.9	187.8	187.8	15.07%	-2.12%
	40.4	43.9	187.8	187.8	21.51%	-8.66%
	53.6	58.9	187.9	187.9	28.53%	-9.89%
	67.6	76.4	188.7	188.7	35.82%	-13.02%
	81.2	94.1	189.9	189.9	42.76%	-15.89%
	95.7	112.4	191.3	191.3	50.03%	-17.45%
	107.6	127.8	191.6	191.6	56.16%	-18.77%
	122.8	146.2	194.5	194.5	63.14%	-19.06%
	135.3	157.8	195	195	69.38%	-16.63%
	146.4	173.6	282.4	282.4	51.84%	-18.58%

K #: 35	SERVICE: NAVY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	28.9	31.6	55	55	52.55%	-9.34%
	35	38	66.9	66.9	52.32%	-8.57%
	41.7	46.4	66.6	66.6	62.61%	-11.27%
	52.3	54.2	94.5	94.5	55.34%	-3.63%
	55.5	62	76.4	76.4	72.64%	-11.71%
	58.1	71.2	77.6	84.6	68.68%	-22.55%
	59.5	78.4	77.1	86.1	69.11%	-31.76%
	61.7	83.9	76.5	86.5	71.33%	-35.98%
	65.2	89.3	78.4	88.4	73.76%	-36.96%
	60.3	89.7	79.4	95.4	63.21%	-48.76%
	60.5	89.9	81.9	97.9	61.80%	-48.60%
	60.3	91.3	76.5	92.5	65.19%	-51.41%
	74.3	93.1	77.8	93.8	79.21%	-25.30%

K #: 36	SERVICE: NAVY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	445.8	489.8	1534	1534	29.06%	-9.87%
	548.4	612	1534	1534	35.75%	-11.60%
	685.1	784.9	1534	1534	44.66%	-14.57%
	809.5	950.8	1537.6	1537.6	52.65%	-17.46%
	919.9	1071.8	1537.6	1537.6	59.83%	-16.51%
	1052.5	1266.5	1545.7	1545.7	68.09%	-20.33%
	1161.1	1431	1546.4	1546.4	75.08%	-23.25%
	1254.3	1552.3	1547.6	1547.6	81.05%	-23.76%
	1296.6	1643.5	1547.6	1941	66.80%	-26.75%
	1345.3	1729.9	1554.4	1941	69.31%	-28.59%
	1377.8	1813.2	1547	1941	70.98%	-31.60%
	1397.8	1861.6	1547	1940.5	72.03%	-33.18%
	1405	1885.6	1547	1940.7	72.40%	-34.21%
	1419.2	1936.1	1547	1941	73.12%	-36.42%

K #: 37	SERVICE: NAVY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: CPAF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	64.3	65.6	550	550	11.69%	-2.02%
	115.8	120	550	550	21.05%	-3.63%
	180.3	190.7	557.7	557.7	32.33%	-5.77%
	258.2	268.3	557.8	557.8	46.29%	-3.91%
	393.4	311.7	557.8	557.8	70.53%	20.77%
	512.8	522.6	2400.5	2400.5	21.36%	-1.91%
	652.6	674.1	2397	2397	27.23%	-3.29%
	832.1	863.6	2394.4	2394.4	34.75%	-3.79%
	960.1	996.7	2394.4	2394.4	40.10%	-3.81%

K #: 38	SERVICE: NAVY	SYSTEM: MISSILE	PHASE: FSD		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	15	11.2	65	65	23.08%	25.33%
	23.3	21.6	128.9	128.9	18.08%	7.30%
	38.6	26.6	131.6	131.6	29.33%	31.09%
	36	33.9	133.4	133.4	26.99%	5.83%
	43	41.4	133.4	133.4	32.23%	3.72%
	57.2	57.2	132.6	132.6	43.14%	0.00%
	67.1	68.4	130.8	130.8	51.30%	-1.94%
	72.1	74.8	133.4	133.4	54.05%	-3.74%

K #: 39	SERVICE: ARMY	SYSTEM: VEHICLE	PHASE: FSD		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	1.8	1.6	44.7	44.7	4.03%	11.11%
	9.5	8.8	44.7	44.7	21.25%	7.37%
	17.3	17.8	44.7	44.7	38.70%	-2.89%
	24.6	26.2	44.7	44.7	55.03%	-6.50%
	31	33.8	49.1	49.1	63.14%	-9.03%
	35.3	40.2	52.3	52.3	67.50%	-13.88%
	41.1	45.8	53.4	59.1	69.54%	-11.44%
	43.4	52.5	53.4	59.8	72.58%	-20.97%
	44.2	57.3	53.4	61.2	72.22%	-29.64%
	47.2	61.3	53.2	60.9	77.50%	-29.87%
	49.4	64.8	54.6	62.4	79.17%	-31.17%
	52.1	67.8	56.5	65.3	79.79%	-30.13%
	53.7	68.5	57	64.7	83.00%	-27.56%

K #: 40	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	44	46.1	805.7	805.7	5.46%	-4.77%
	119.1	128.8	812.1	812.1	14.67%	-8.14%
	264.2	277.1	801.4	801.4	32.97%	-4.88%
	420.4	428.9	804.4	804.4	52.26%	-2.02%
	553.8	561.3	806.1	806.1	68.70%	-1.35%
	632.7	646.7	811.5	811.5	77.97%	-2.21%
	679.2	703.2	813.1	813.1	83.53%	-3.53%
	728.5	747.2	812.6	812.6	89.65%	-2.57%
	768.2	786.4	813.5	813.5	94.43%	-2.37%
	781.5	802.1	817.6	817.6	95.58%	-2.64%
	793.9	814.9	817.4	817.4	97.13%	-2.65%
	802.6	824.7	817.8	817.8	98.14%	-2.75%
	804.8	831	819.7	819.7	98.18%	-3.26%
	808.1	832.6	821.1	821.1	98.42%	-3.03%
	808.6	833.8	835.3	835.3	96.80%	-3.12%
	809.2	834.1	839.2	839.2	96.43%	-3.08%

K #: 41	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: FPI	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	45.6	46.3	434.6	434.6	10.49%	-1.54%
	109.1	114.2	430.3	430.3	25.35%	-4.67%
	150.6	163.1	439.5	439.5	34.27%	-8.30%
	230.2	246.2	553.6	553.6	41.58%	-6.95%
	297.8	314.6	561.1	561.1	53.07%	-5.64%
	342.8	363	567.9	567.9	60.36%	-5.89%
	412.9	433.9	581	581	71.07%	-5.09%
	456.5	481.8	589.7	589.7	77.41%	-5.54%
	500.1	526.1	609.9	609.9	82.00%	-5.20%
	531.9	558.4	644.9	644.9	82.48%	-4.98%
	554.2	585.9	650.6	650.6	85.18%	-5.72%
	579.9	619.9	666.5	666.5	87.01%	-6.90%
	586.5	630	666.1	666.1	88.05%	-7.42%

K #: 42	SERVICE: NAVY	SYSTEM: ELECTRONICS	PHASE: FSD		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	5.4	22.4	292.1	292.1	1.85%	-314.81%
	39.8	42.3	292.1	292.1	13.63%	-6.28%
	50.1	58.4	308.3	308.3	16.25%	-16.57%
	79.2	80.7	308.3	308.3	25.69%	-1.89%
	99.5	100.5	308.6	308.6	32.24%	-1.01%
	113.7	125.3	369.8	369.8	30.75%	-10.20%
	135.2	147.1	369.8	369.8	36.56%	-8.80%
	171.7	182.3	388.2	388.2	44.23%	-6.17%
	186.1	208.8	388.2	388.2	47.94%	-12.20%
	193.9	220.8	379.3	379.3	51.12%	-13.87%
	216.8	248.8	387.1	387.1	56.01%	-14.76%
	229.8	276.7	387.1	387.1	59.36%	-20.41%
	243.8	299	385.2	385.2	63.29%	-22.64%
	225.1	291	386.9	386.9	58.18%	-29.28%
	240.9	313.9	387.1	387.1	62.23%	-30.30%
	259.2	337.7	386.3	386.3	67.10%	-30.29%
	281	366.9	389.8	389.8	72.09%	-30.57%
	296.4	390	389.5	389.5	76.10%	-31.58%
	321.2	420.5	390.7	390.7	82.21%	-30.92%
	342	439.6	390.3	390.3	87.62%	-28.54%
	366.6	469.6	390.7	390.7	93.83%	-28.10%

K #: 43	SERVICE: AF	SYSTEM: MISSILE	PHASE: DEV		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	3.6	2.7	87.9	87.9	4.10%	25.00%
	21.5	23.1	119.1	119.1	18.05%	-7.44%
	39.3	43	119.1	119.1	33.00%	-9.41%
	52.2	57.2	119.2	119.2	43.79%	-9.58%
	65.1	74.4	120.1	120.1	54.20%	-14.29%
	78.1	90.6	122.4	122.4	63.81%	-16.01%
	89.5	106.1	130.2	130.2	68.74%	-18.55%
	98.1	120	132.9	132.9	73.81%	-22.32%
	105.2	135.4	133.6	133.6	78.74%	-28.71%
	109.8	144.6	133.3	133.3	82.37%	-31.69%
	117.1	155	133.6	133.6	87.65%	-32.37%
	119.5	166.4	133.7	133.7	89.38%	-39.25%

K #: 44	SERVICE: AF	SYSTEM: SATELLITE	PHASE: FSD		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	100	132.8	570.7	570.7	17.52%	-32.80%
	108.5	148.2	570.7	570.7	19.01%	-36.59%
	125.9	177.7	572.9	572.9	21.98%	-41.14%
	150.4	219.2	581.6	581.6	25.86%	-45.74%
	288.3	450.2	593.8	593.8	48.55%	-56.16%
	337	523.2	611.4	611.4	55.12%	-55.25%
	388.3	549.7	656.4	656.4	59.16%	-41.57%
	458.6	629.2	731.7	731.7	62.68%	-37.20%
	536.5	722.1	737.6	737.6	72.74%	-34.59%
	609.7	816.5	747.9	747.9	81.52%	-33.92%
	629.1	866.6	757.6	757.6	83.04%	-37.75%
	651.2	909.5	795.2	795.2	81.89%	-39.67%
	689.9	969.6	802.2	802.2	86.00%	-40.54%
	729.2	995.3	824	1114.3	65.44%	-36.49%
	760.1	1046.9	821.7	1115.5	68.14%	-37.73%
	804.3	1062.3	870.3	1119.8	71.83%	-32.08%
	820.4	1088.5	873.9	1158.5	70.82%	-32.68%

K #: 45	SERVICE: NAVY	SYSTEM: ELECTRONICS	PHASE: FSD		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	1.1	0.6	80.7	80.7	1.36%	45.45%
	4.2	3.7	80.7	80.7	5.20%	11.90%
	10.2	9.5	80.7	80.7	12.64%	6.86%
	17.7	17.2	81.4	81.4	21.74%	2.82%
	26.3	25.8	85.5	85.5	30.76%	1.90%
	36.3	39.2	100.7	100.7	36.05%	-7.99%
	45	54	100.7	100.7	44.69%	-20.00%
	47.5	58.4	101	101	47.03%	-22.95%
	82.3	81.7	147	147	55.99%	0.73%
	92.6	93	147	147	62.99%	-0.43%
	104.4	109.3	147	147	71.02%	-4.69%
	107.2	116.5	147	147	72.93%	-8.68%
	118.1	132.4	147	147	80.34%	-12.11%
	123.1	146.9	147	147	83.74%	-19.33%
	126.7	152.2	147	147	86.19%	-20.13%

K #: 46	SERVICE: AF	SYSTEM: MISSILE	PHASE: FSD		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	27.1	27.8	441	441	6.15%	-2.58%
	43.6	43.9	483.2	483.2	9.02%	-0.69%
	67.3	66	126.2	126.2	53.33%	1.93%
	81.3	80.8	119.7	119.7	67.92%	0.62%
	93.5	96.7	119.7	119.7	78.11%	-3.42%
	106.3	106.8	119.7	119.7	88.81%	-0.47%
	115.6	115.5	137.7	137.7	83.95%	0.09%
	118.9	119.6	137.7	137.7	86.35%	-0.59%
	123.9	124.9	139.9	139.9	88.56%	-0.81%
	129.5	129.9	138.4	138.4	93.57%	-0.31%
	135	135.1	166.5	166.5	81.08%	-0.07%
	138.9	139.5	166.4	166.4	83.47%	-0.43%
	146.3	147.2	166.4	166.4	87.92%	-0.62%
	160.3	161.1	172.1	172.1	93.14%	-0.50%
	168.9	169.3	172.1	172.1	98.14%	-0.24%

K #: 47	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	0.01	3.7	86.4	86.4	0.01%	NA
	8.7	10.1	84.4	84.4	10.31%	-16.09%
	16.8	20.9	93.5	93.5	17.97%	-24.40%
	79.6	80.7	163.2	163.2	48.77%	-1.38%
	93.6	90.5	163.6	163.6	57.21%	3.31%
	109.9	111.1	163.7	163.7	67.14%	-1.09%
	130.7	131.9	164.5	164.5	79.45%	-0.92%
	143	146	170.8	170.8	83.72%	-2.10%
	151.1	156.6	169.7	169.7	89.04%	-3.64%
	156.8	163.5	170.5	170.5	91.96%	-4.27%
	160.2	167.8	172.4	172.4	92.92%	-4.74%
	163.9	171.4	172.8	172.8	94.85%	-4.58%
	166.2	175.6	174.2	174.2	95.41%	-5.66%

K #: 48	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	0.5	0.5	43.5	43.5	1.15%	0.00%
	2	2	43.5	43.5	4.60%	0.00%
	4.5	4.5	43.5	43.5	10.34%	0.00%
	12.2	11.4	43.5	43.5	28.05%	6.56%
	21.8	21.9	43.6	43.6	50.00%	-0.46%
	27.8	28.6	49.9	49.9	55.71%	-2.88%
	35.7	37.6	50	50	71.40%	-5.32%
	41.4	45.7	50.5	50.5	81.98%	-10.39%
	47.1	53.4	63	63	74.76%	-13.38%
	52.2	61.8	62.8	62.8	83.12%	-18.39%
	55.2	67.9	62.9	62.9	87.76%	-23.01%
	60	73	66.9	66.9	89.69%	-21.67%
	62.3	77.9	66	66	94.39%	-25.04%
	64.7	78.3	66.8	78.1	82.84%	-21.02%

K #: 49	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	15	15.9	100.3	100.3	14.96%	-6.00%
	22.1	24	101.1	101.1	21.86%	-8.60%
	29	34.8	101.1	101.1	28.68%	-20.00%
	35	45.8	101.1	101.1	34.62%	-30.86%
	50.6	80.5	101.8	101.8	49.71%	-59.09%
	75.2	103.9	105.7	143	52.59%	-38.16%
	81.6	114.7	109	146.3	55.78%	-40.56%
	87	130.8	109	146.3	59.47%	-50.34%
	91.6	148.6	109	146.3	62.61%	-62.23%
	94.2	170.6	107.3	146.7	64.21%	-81.10%
	100.6	200.4	106.4	146.7	68.58%	-99.20%

K #: 50	SERVICE: AF	SYSTEM: AIRCRAFT	PHASE: DEV		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	14	14	108.9	108.9	12.86%	0.00%
	21.6	21	108.9	108.9	19.83%	2.78%
	33.4	33.4	108.9	108.9	30.67%	0.00%
	38.1	39.4	108.9	108.9	34.99%	-3.41%
	47.1	48.6	108.9	108.9	43.25%	-3.18%
	56.3	58.5	108.9	108.9	51.70%	-3.91%
	68.3	72.4	112.7	109.7	62.26%	-6.00%
	74.9	84.8	112.7	112.7	66.46%	-13.22%
	82.8	95.3	111.4	111.4	74.33%	-15.10%
	87.9	103.4	111.7	111.4	78.90%	-17.63%
	95.7	112.9	112.3	112.3	85.22%	-17.97%

K #: 51	SERVICE: NAVY	SYSTEM: ELECTRONICS	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	1.1	1.1	80.8	80.8	1.36%	0.00%
	6.2	5.3	80.8	80.8	7.67%	14.52%
	10.4	11.1	80.8	80.8	12.87%	-6.73%
	21.3	26.7	88.1	88.1	24.18%	-25.35%
	28.6	40.2	88.1	88.1	32.46%	-40.56%
	73.6	84.2	88.7	88.7	82.98%	-14.40%
	63.7	103.6	88.7	88.7	71.82%	-62.64%
	68.1	116.9	88.7	88.7	76.78%	-71.66%
	74.9	139.4	88.8	88.8	84.35%	-86.11%
	77	148.8	88.8	88.8	86.71%	-93.25%
	113.5	168.1	128.3	128.3	88.46%	-48.11%
	112.8	165	128.3	128.3	87.92%	-46.28%

K #: 52	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: DEV		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	20.4	20.3	162.7	162.7	12.54%	0.49%
	27.8	27.6	162.7	162.7	17.09%	0.72%
	31.5	32.3	162.8	162.8	19.35%	-2.54%
	36.4	37.1	162.8	162.8	22.36%	-1.92%
	41.4	41.8	162.8	162.8	25.43%	-0.97%
	45.3	45.6	162.8	162.8	27.83%	-0.66%
	50.4	49.7	163	163	30.92%	1.39%
	55.1	55.2	163	163	33.80%	-0.18%
	59.1	59.8	163	163	36.26%	-1.18%
	70.6	71.7	163	163	43.31%	-1.56%
	92.4	96.1	163.3	163.3	56.58%	-4.00%
	99.6	104.5	164.5	164.5	60.55%	-4.92%
	112.4	117.3	165.1	165.1	68.08%	-4.36%
	122.2	130.3	165.1	165.1	74.02%	-6.63%
	132.4	141.3	165.1	165.1	80.19%	-6.72%
	142	152.4	165.1	165.1	86.01%	-7.32%
	149.8	162.7	165.1	165.1	90.73%	-8.61%
	155.3	171.1	165.1	165.1	94.06%	-10.17%
	159.4	178.6	165.1	165.1	96.55%	-12.05%
	163.4	178.5	165.2	165.2	98.91%	-9.24%
	164.2	180.5	165.2	165.2	99.39%	-9.93%
	164.7	181.5	165.2	165.2	99.70%	-10.20%

K #: 53	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: DEV		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	39.1	41.3	343.5	343.5	11.38%	-5.63%
	64.3	68.8	343.5	343.5	18.72%	-7.00%
	92.2	102.6	343.5	343.5	26.84%	-11.28%
	121	137.4	343.5	343.5	35.23%	-13.55%
	132.9	150.7	343.5	343.5	38.69%	-13.39%
	184.2	184.2	343.5	343.5	53.62%	0.00%
	226.8	231.5	343.5	343.5	66.03%	-2.07%
	251.1	257.9	343.5	343.5	73.10%	-2.71%
	269.8	280.1	422.8	422.8	63.81%	-3.82%
	281.4	291.7	422.8	422.8	66.56%	-3.66%
	305.2	318.4	422.8	422.8	72.19%	-4.33%
	315.1	330.8	422.8	422.8	74.53%	-4.98%
	359	359	518.3	518.3	69.26%	0.00%
	377.8	377.7	499	499	75.71%	0.03%
	390.9	388.9	499	499	78.34%	0.51%

K #: 54	SERVICE: AF	SYSTEM: ELECT	PHASE: DEV		K TYPE: CPAF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	0.8	0.8	71	71	1.13%	0.00%
	1.6	1.6	71	71	2.25%	0.00%
	2.7	2.5	72.1	72.1	3.74%	7.41%
	4.4	4.2	72.1	72.1	6.10%	4.55%
	5.6	5.7	72.1	72.1	7.77%	-1.79%
	7.9	8.2	72.1	72.1	10.96%	-3.80%
	10.7	11.5	72.1	72.1	14.84%	-7.48%
	13.1	14.8	72.1	72.1	18.17%	-12.98%
	15.3	17.6	72.1	72.1	21.22%	-15.03%
	17.7	21.8	72.1	72.1	24.55%	-23.16%
	20.5	26.3	72.1	72.1	28.43%	-28.29%
	23	29.7	72.1	72.1	31.90%	-29.13%
	26.4	34.6	72.1	87.9	30.03%	-31.06%
	29	39	72.1	87.9	32.99%	-34.48%
	33.5	46.1	72.1	87.9	38.11%	-37.61%
	35.2	49.7	72.6	88.3	39.86%	-41.19%
	37.7	54.1	72.6	88.3	42.70%	-43.50%
	39.1	57.2	72.6	88.3	44.28%	-46.29%
	40.9	61.1	72.6	88.3	46.32%	-49.39%
	50.1	81.3	72.8	88.7	56.48%	-62.28%

K #: 55	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: DEV		K TYPE: CP	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	11.3	11.6	43.6	43.6	25.92%	-2.65%
	15.4	15.6	43.9	43.9	35.08%	-1.30%
	20.1	21.1	49.3	49.3	40.77%	-4.98%
	26	27.1	50.2	50.2	51.79%	-4.23%
	31.1	34.2	51.5	51.5	60.39%	-9.97%
	35.4	40.6	54.6	54.6	64.84%	-14.69%
	37.4	43	54.9	54.9	68.12%	-14.97%
	47.8	55.9	59.2	65.4	73.09%	-16.95%
	54.8	60.9	60.9	65.4	83.79%	-11.13%
	60.7	67.5	70.8	77.5	78.32%	-11.20%
	64.4	74.9	67.5	72	89.44%	-16.30%
	66.3	77	67.8	71.8	92.34%	-16.14%
	66.4	78	67.5	72	92.22%	-17.47%

K #: 56	SERVICE: AF	SYSTEM: SUPPORT	PHASE: DEV		K TYPE: FPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	102.3	96.4	128.1	128.1	79.86%	5.77%
	103.2	97	128.1	128.1	80.56%	6.01%
	104.3	98.1	128.4	128.4	81.23%	5.94%
	105.1	98.6	128.5	128.5	81.79%	6.18%
	105.9	99.4	128.6	128.6	82.35%	6.14%
	107.4	100.7	129.5	129.5	82.93%	6.24%
	109.3	101.7	129.9	129.9	84.14%	6.95%
	110.1	102.2	129.9	129.9	84.76%	7.18%
	112.6	104.2	131.7	131.7	85.50%	7.46%
	115.9	107.6	131.7	131.7	88.00%	7.16%
	117.6	109.3	131.8	131.8	89.23%	7.06%
	119.9	111.4	134	134	89.48%	7.09%
	121.7	112.5	135.8	135.8	89.62%	7.56%
	123.3	113.9	134.2	134.2	91.88%	7.62%

K #: 57	SERVICE: AF	SYSTEM: MISSILE	PHASE: DEV		K TYPE: FPI	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	16.1	16.3	30.7	30.7	52.44%	-1.24%
	18.9	18.9	32.5	32.5	58.15%	0.00%
	21.6	21.8	33.5	33.5	64.48%	-0.93%
	25.2	25.1	34.3	34.3	73.47%	0.40%
	27.2	27.1	34.3	34.3	79.30%	0.37%
	29	28.7	34.3	34.3	84.55%	1.03%
	32.1	32.4	34.9	34.9	91.98%	-0.93%
	33.1	33.7	38.1	38.1	86.88%	-1.81%

K #: 58	SERVICE: ARMY	SYSTEM: MISSILE	PHASE: DEV		K TYPE: CPIF	
	BCWP	ACWP	CBB	ALLOC BUDGET	COMPL PT	CV
	30.4	30.8	238.8	238.8	12.73%	-1.32%
	33.1	32.9	238.8	238.8	13.86%	0.60%
	38.1	38.7	238.8	238.8	15.95%	-1.57%
	44.2	45.8	238.8	238.8	18.51%	-3.62%
	50.2	51.9	238.8	238.8	21.02%	-3.39%
	56.8	59.6	238.8	238.8	23.79%	-4.93%
	62.5	65.7	238.8	238.8	26.17%	-5.12%
	69.6	74.2	238.8	238.8	29.15%	-6.61%
	88.9	96.7	238.8	238.8	37.23%	-8.77%
	94.9	109	236.8	272.5	34.83%	-14.86%
	112.1	129.8	236.8	272.5	41.14%	-15.79%
	128.3	151.1	236.8	272.5	47.08%	-17.77%
	145.1	173.2	236.8	272.5	53.25%	-19.37%
	159.6	193.6	237.9	273.6	58.33%	-21.30%
	175.7	214.8	240.5	276.2	63.61%	-22.25%
	206.2	260.1	241.1	289.5	71.23%	-26.14%
	218.4	277.8	241.1	289.5	75.44%	-27.20%
	226.3	291	241.4	289.8	78.09%	-28.59%
	230.7	301.2	241.4	289.8	79.61%	-30.56%
	234.9	309.5	241.7	290.3	80.92%	-31.76%

APPENDIX B. STATISTICAL INFORMATION

This appendix provides the detailed statistical information to support information contained in the text. The appendix is subdivided into the following sections:

A. Modeling of the Data.

B. Distribution Information

C. Beta Value Conversions

D. Non-parametric Tests

A. MODELING OF THE DATA

The accuracy of the A-12 percentile values is dependent on how well the data were modeled by the specified parameters. To ensure that the percentile values were not biased by the choice of distribution, each data set was checked with a second distribution. This section contains the graphical representations of the distribution of the data. The graphs in this section were produced using BestFit [Ref. 20].

1. Sample: 0 to 10 Percent Complete

Figure 7 shows the distribution of cost variances for all contracts from 0 to 10 percent complete. The data were best modeled by the Normal distribution, with mean equal to 1.79 and standard deviation of 11.56.

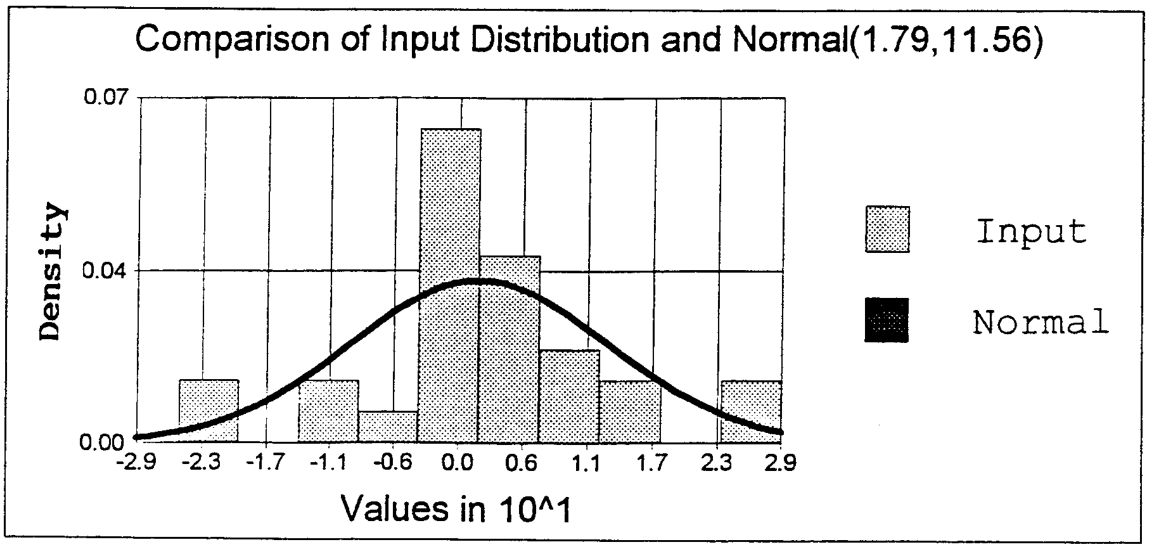

Figure 7. Sample Data 0 to 10 Percent Complete.

2. Sample Data: 11 to 20 Percent Complete.

Figure 8 shows the distribution for cost variances of the sample, from 11-20 percent complete. Thirty-seven contracts were included in the sample. The data were skewed to the left, and were best represented by the Beta distribution with parameters (2.3, 1.07).

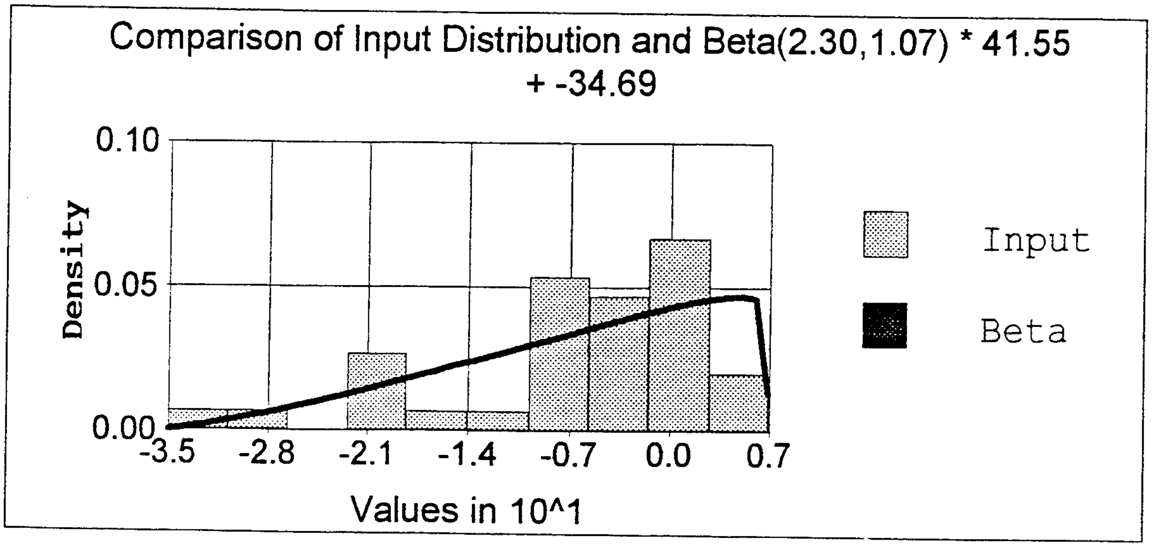

Figure 8. Sample Data 11 to 20 Percent Complete.

3. Sample Data: 21 to 30 Percent Complete

Figure 9 is the distribution of cost variances for contracts 21 to 30 percent complete. Thirty-four contracts constitute the sample. The data were centered near zero and were modeled by the Logistic distribution with parameters (-5.27, 11.10).

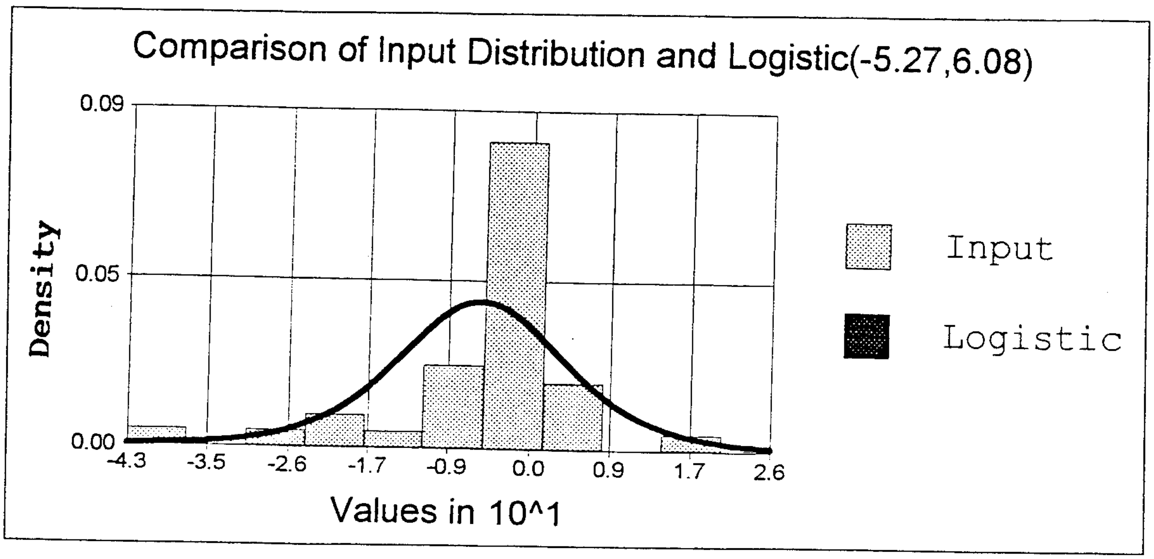

Figure 9. Sample Data 21 to 30 Percent Complete.

4. Sample Data 31 to 40 Percent Complete

Figure 10 is the distribution of cost variances in programs 31 to 40 percent complete. Thirty-seven contracts constitute the sample. The sample is modeled by the Logistic distribution with parameters (-8.08, 5.54).

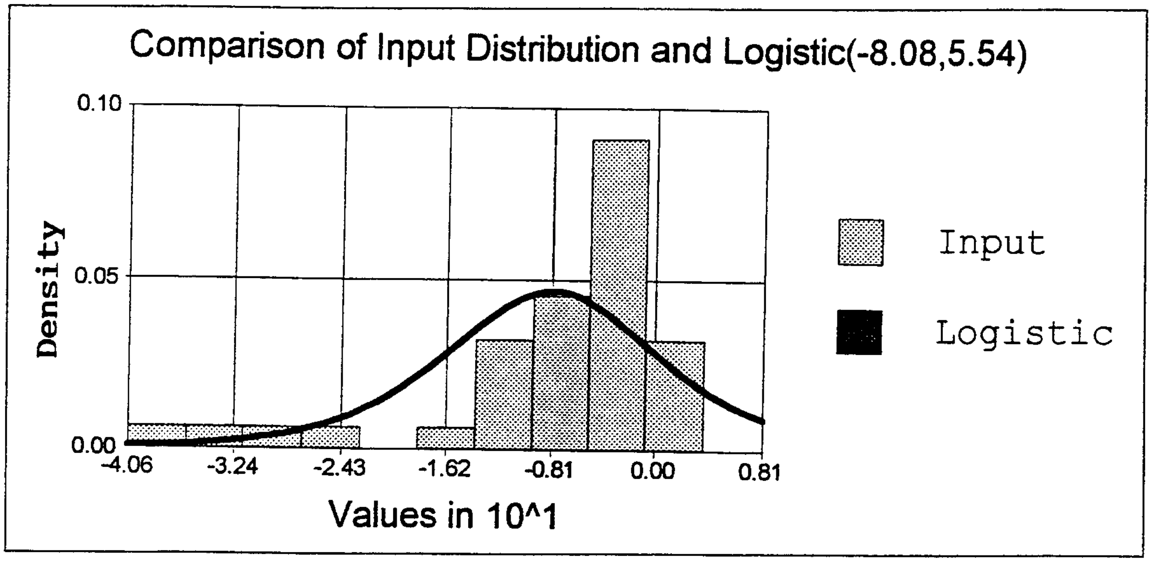

Figure 10. Sample Data 31 to 40 Percent Complete.

5. Sample Data 41 to 50 Percent Complete

Figure 11 is the distribution of cost variances in programs 41 to 50 percent complete. The data are skewed to the left. However, the degree of skewness does not warrant the selection of a Beta distribution. The Logistic distribution models the data. The parameters of the distribution are (-11.02, 8.08).

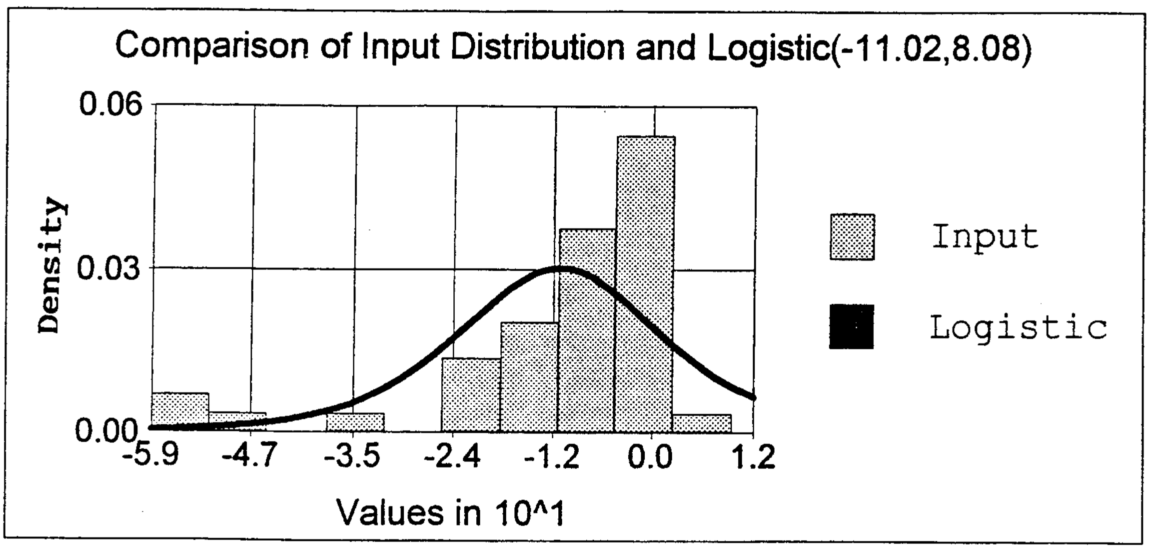

Figure 11. Sample Data 41 to 50 Percent Complete.

6. Aircraft Programs: 0 to 10 Percent Complete

Figure 12 provides the distribution of cost variances within aircraft programs, from 0 to 10 percent complete. Eleven contracts are used. The distribution is centered near zero. The data are modeled by the Beta distribution with parameters (1.75, .83).

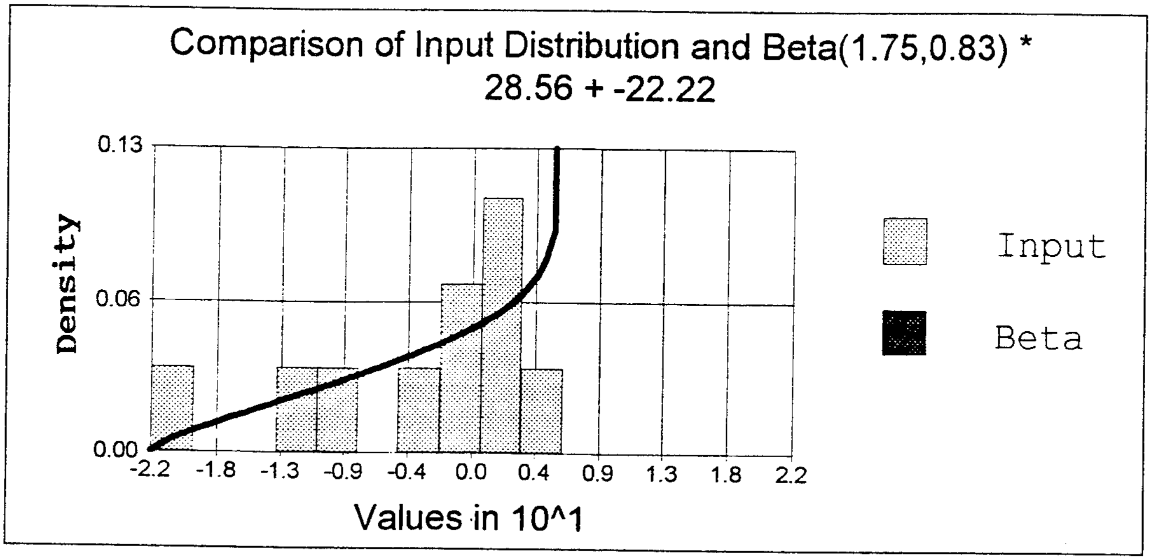

Figure 12. Aircraft Programs 0 to 10 Percent Complete.

7. Aircraft Programs: 11 to 20 Percent Complete

Figure 13 provides the distribution of cost variances in aircraft programs 11 to 20 percent complete. The Beta distribution modeled the data. Eleven contracts were in the sample. The parameters of the distribution are (1.17, .56).

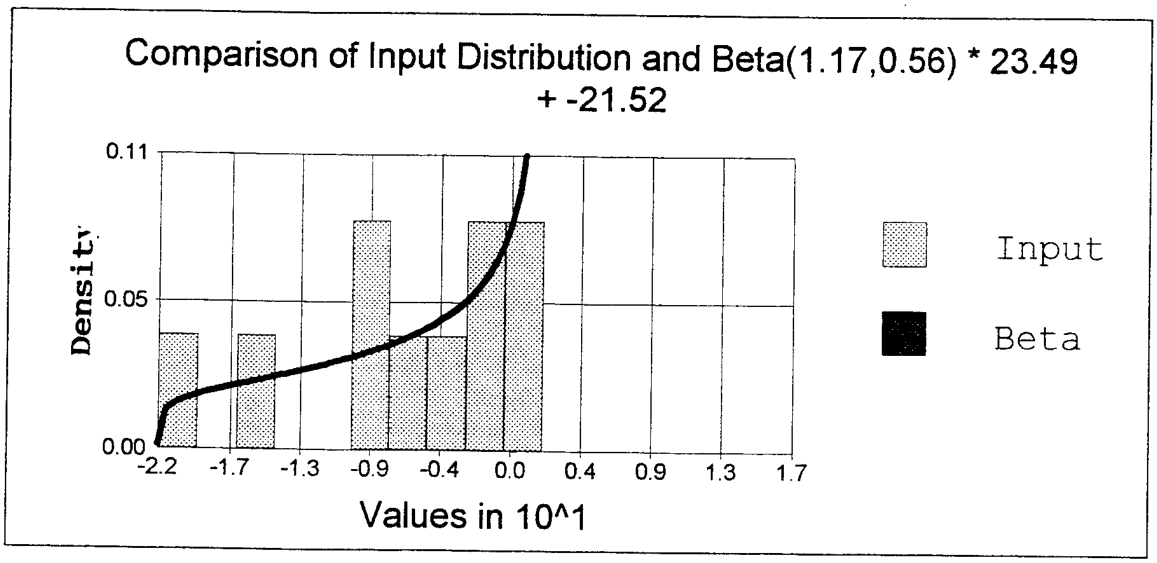

Figure 13. Aircraft Programs 11 to 20 Percent Complete.

8. Aircraft Programs: 21 to 30 Percent Complete

Figure 14 provides the cost variance distribution for aircraft programs 21 to 30 percent complete. The Beta distribution models the data with parameters (1.43, .64). Twelve contracts were included in the sample.

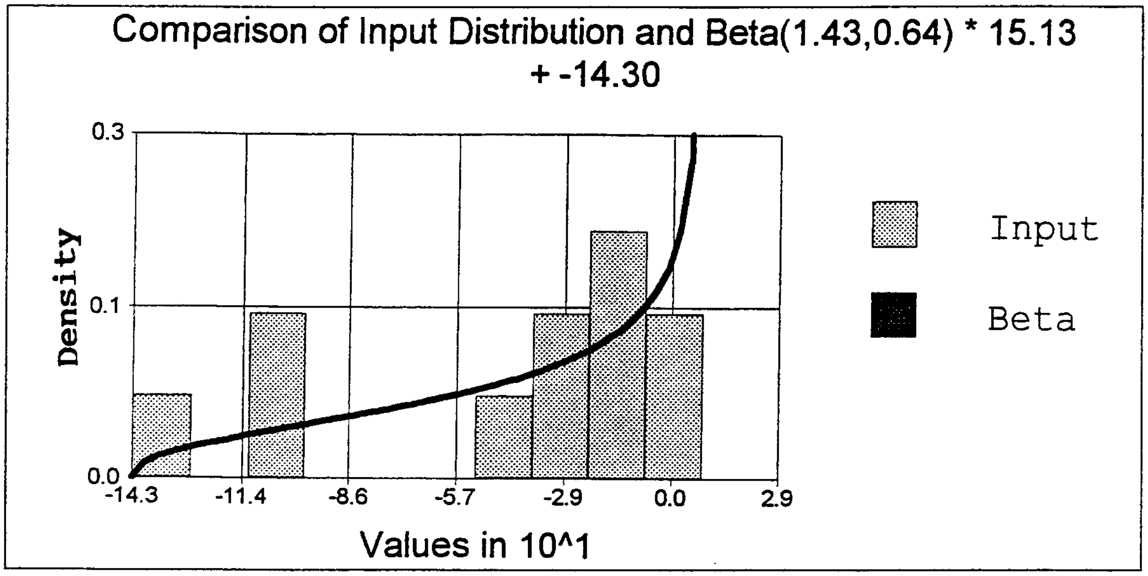

Figure 14. Aircraft Programs 21 to 30 Percent Complete.

9. Aircraft Programs: 31 to 40 Percent Complete

Figure 15 provides the distribution of cost variances in aircraft programs 31 to 40 percent complete. The data are skewed to the left and are modeled by the Beta distribution. Fourteen contracts were included in the sample. The parameters of the distribution are (2.05, .94).

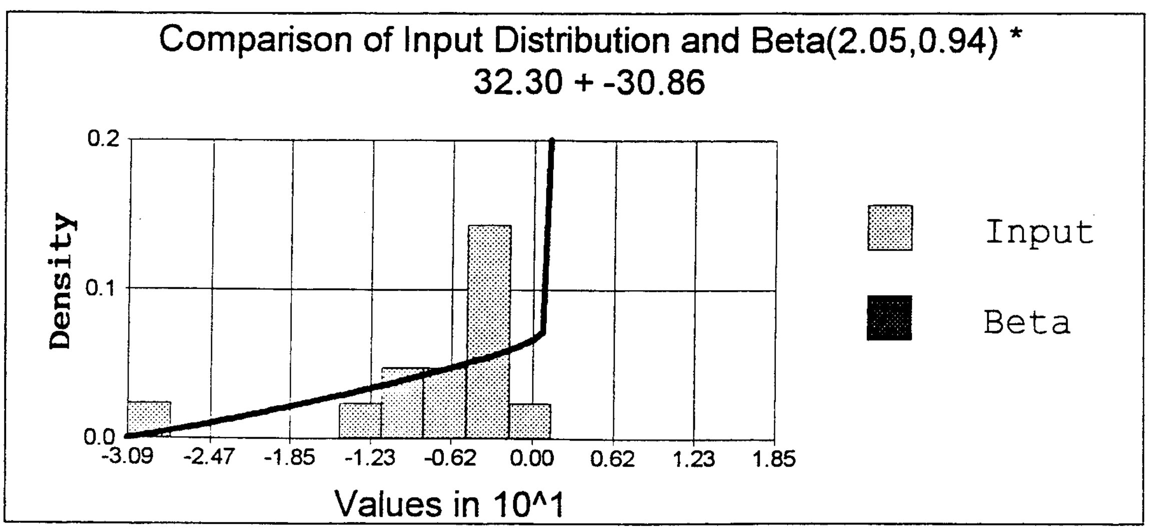

Figure 15. Aircraft Programs 31 to 40 Percent Complete.

10. Aircraft Programs: 41 to 50 Percent Complete

Figure 16 provides the distribution of cost variances within aircraft programs 41 to 50 percent complete. The data are modeled by the Logistic distribution with parameters (-12.63, 10.16). Ten contracts were included in the sample.

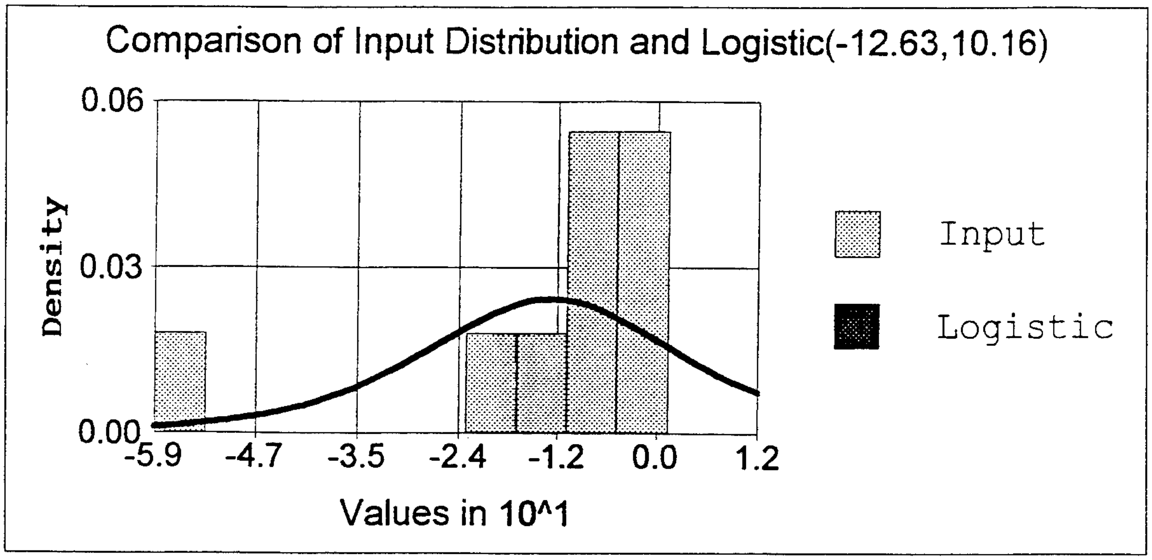

Figure 16. Aircraft Programs 41 to 50 Percent Complete.

11. Sample Contracts Cost Variance Distribution

Figure 17 provides the distribution of cost variances for all programs that had met or exceeded 80 percent complete. Forty contracts were included in the sample. The distribution was skewed to the left and was modeled by the Beta distribution. The parameters of the distribution are (1.49, .82).

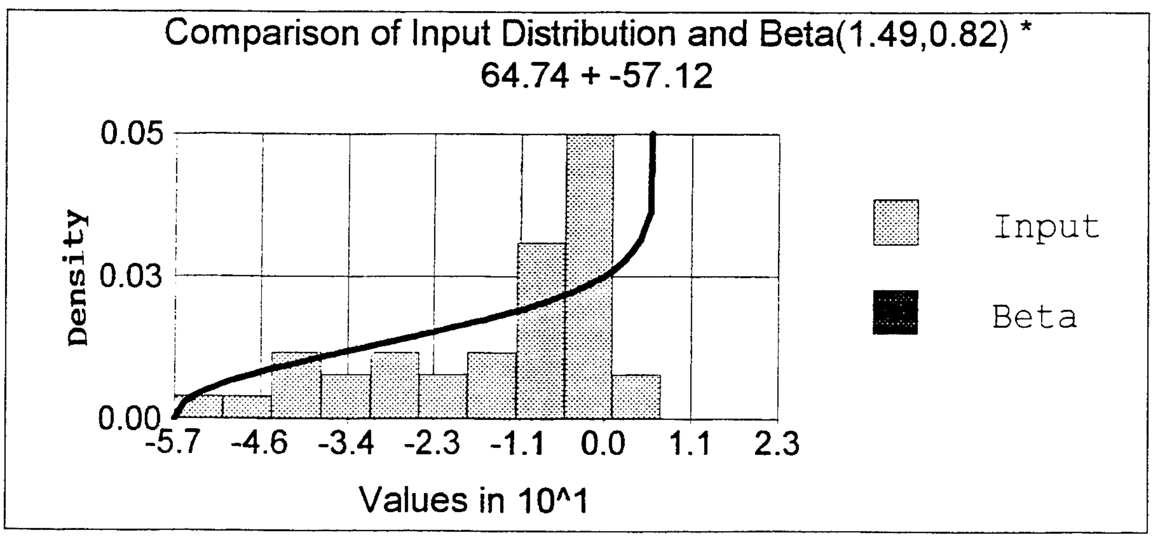

Figure 17. All Contracts at Least 80 Percent Complete.

12. Distribution of Cost Contracts

Figure 18 provides the distribution of cost variances, for programs with cost-type contracts, at least 50 percent complete. The data are skewed to the left and are modeled by the Beta distribution. Thirty-nine contracts were included in the sample. The parameters of the distribution are (1.65, .40).

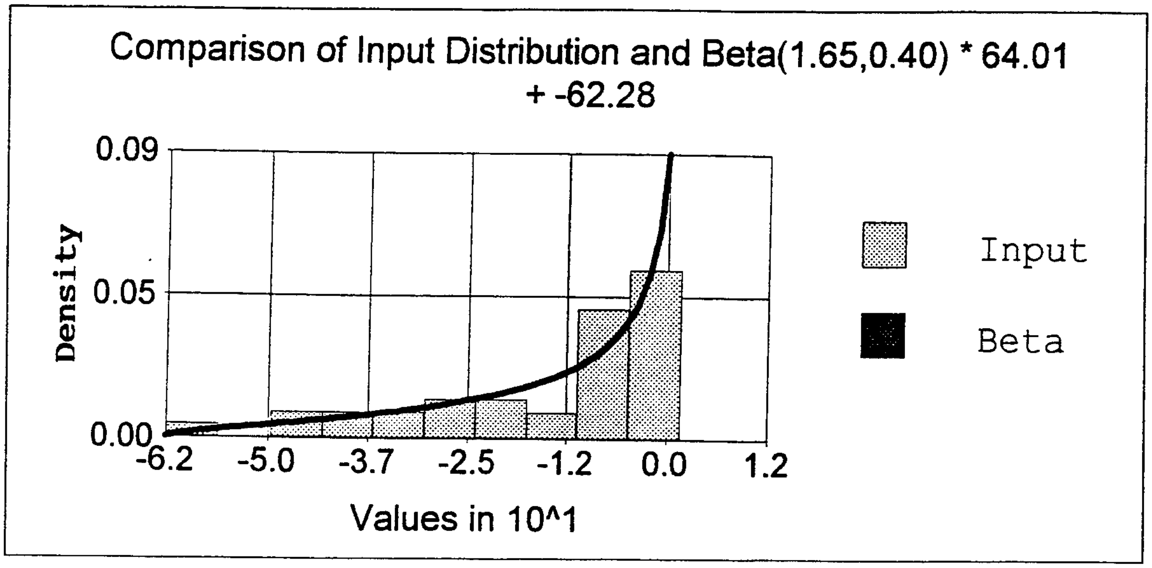

Figure 18. All Cost-Type Contracts at Least 50 Percent Complete.

13. Distribution of Fixed-Price Contracts

Figure 19 provides the cost variances for programs with fixed-price type contracts that are at least 50 percent complete. The number of contracts included in the sample is 15. The parameters of the Beta distribution are (.95, .22).

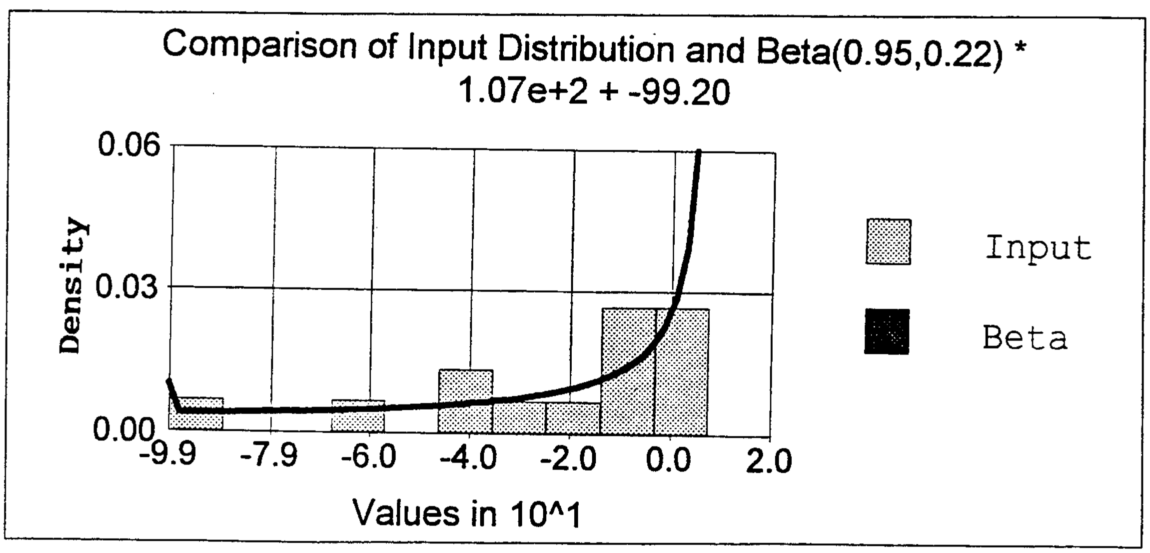

Figure 19. All Fixed-Price Contracts at Least 50 Percent Complete.

15. Distribution of Contract Budget Base Adjustments

Figure 20 shows the distribution of adjustments to the Contract Budget Base, for all programs. The programs included had to be at least 70 percent complete and have 50 percent of the total program included in the cost reports. The distribution of CBB adjustments is modeled by the Logistic distribution with parameters (53.57, 30.21). Twenty-nine contracts were included in the sample.

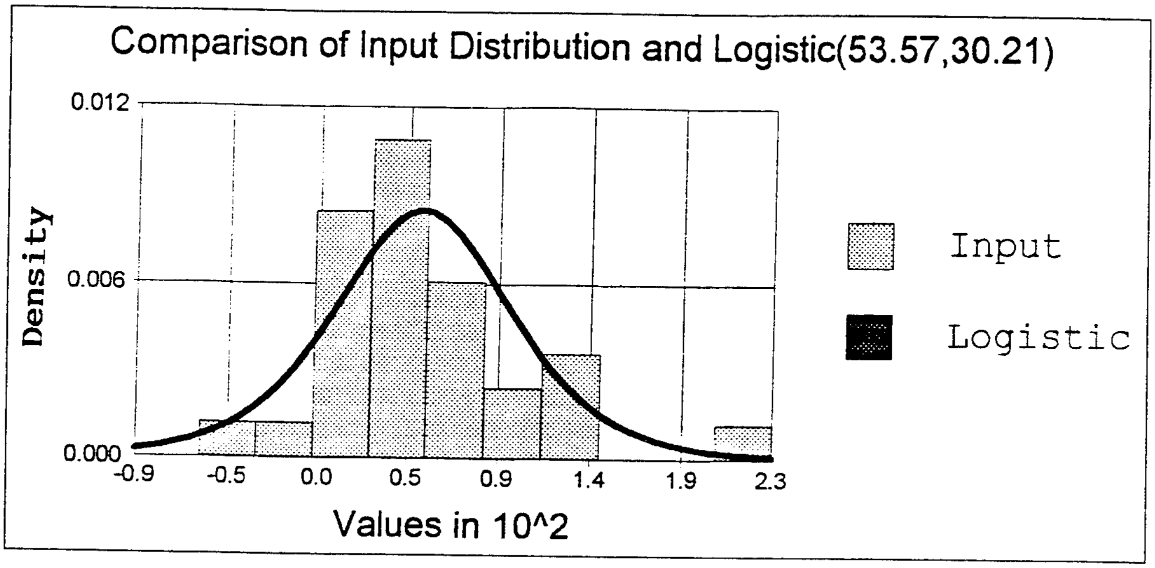

Figure 20. Contract Budget Base Adjustments for the Sample.

B. DISTRIBUTION INFORMATION

1. Statistics of the Distributions

Table 21 gives the detailed statistics of the distributions that best modeled the data. Column 1 is the type sample that is modeled. Column 2 provides the percentage completion brackets. In Columns 3 and 4 are the distribution's parameters. In Columns 5 and 6 are the extreme values for the data. The extreme values do not include outliers that were discarded. The best distribution that modeled the data and the second best distribution are given in Columns 7 and 8. The accompanying Chi-squared values are provided in Columns 9 and 10.

SAMPLE	% COMPL	PARAM 1	PARAM 2	HI	LO	BEST DISTRO	2ND BEST DISTRO	BEST X^2	2ND BEST X^2
ALL	0 - 10	1.79	11.56	28.68	-25	Normal	Logistic	17.56	17.13
ALL	11 - 20	2.03	1.07	6.86	-34.69	Beta	Logistic	16.55	19.89
ALL	21 - 30	-5.27	6.08	20.75	-43.44	Logistic	Normal	26.84	40.36
ALL	31 - 40	-8.08	5.54	3.72	-40.56	Logistic	Normal	26.04	33.94
ALL	41 - 50	-11.02	8.08	9.31	-59.09	Logistic	Normal	49.93	74.01
ACFT	0 - 10	1.75	0.83	6.34	-22.22	Beta	Normal	9.04	10.17
ACFT	11 - 20	1.17	0.56	1.97	-27.85	Beta	Normal	4.84	8.86
ACFT	21 - 30	1.43	0.64	0.83	-14.3	Beta	Normal	9.69	14.18
ACFT	31 - 40	2.05	0.94	1.44	-30.86	Beta	Logistic	17.62	24.59
ACFT	41 - 50	-12.63	10.16	1.4	-59.09	Logistic	Beta	20.51	5.64
FP ONLY	> 50%	-22.39	15.76	7.62	-99.2	Logistic	Beta	18.76	5.68
COST ONLY	> 50%	1.65	0.4	1.73	-62.28	Beta	Normal	5.76	33.16
ALL	> 80%	1.49	0.82	7.62	-57.12	Beta	Logistic	21.34	29.25
ALL CBB	NA	53.67	30.21	232.68	-60.97	Logistic	Normal	12.19	18.43

Table 21. Detailed Distribution Information.

2. Percentile Value Information

Table 22 contains the percentile values for the samples based on the best and second best distributions. Columns 1 and 2 give the sample type and the percentage completion bracket. Columns 3 and 4 provide the 0 to 1 Beta value, if applicable. In Columns 5 and 6 are the .01 percentile and .05 percentile values for the given distribution. The next best percentile values are given in Columns 7 and 8.

SAMPLE	% COMPL	.05 0 to 1 BETA	.01 0 to 1 BETA	BEST 0.05	BEST 0.01	2ND BEST 0.05	2ND BEST 0.01
ALL	0 - 10			-17.22	-25.10	-17.13	-19.88
ALL	11 - 20	0.2600	0.1300	-23.85	-29.33		
ALL	21 - 30			-23.17	-33.21	-22.03	-28.47
ALL	31 - 40			-24.39	-33.53	-23.52	-31.09
ALL	41 - 50			-34.81	-48.15	-24.72	-31.62
ACFT	0 - 10	0.2100	0.0800	-16.33	-19.85	-37.52	-47.73
ACFT	11 - 20	0.1300	0.0300	-24.00	-26.86	-17.50	-23.29
ACFT	21 - 30	0.1800	0.0600	-11.65	-13.42	-18.40	-23.48
ACFT	31 - 40	0.2400	0.1100	-23.06	-27.29	-12.41	-15.71
ACFT	41 - 50			-42.54	-59.32	-43.14	-55.78
FP ONLY	> 50%			-47.79	-51.75	-68.79	-94.81
COST ON	> 50%	0.3030	0.1194	-42.73	-54.52	-40.80	-51.77
ALL	> 80%	0.1566	0.0536	-46.98	-53.65	-37.09	-56.05
ALL CBB	NA			142.51	192.39	144.30	181.69

Table 22. Percentile Value Information.

C. BETA VALUE CONVERSIONS

The Beta distribution is a continuous distribution, with range 0 to 1. Cost variances can vary from negative infinity to positive infinity. To model cost variances using a Beta distribution the observed values must be converted to a range of 0 to 1. This is accomplished by using the following formula: $b(\beta\colon v, w) + a[1\text{-}(\beta\colon v, w)]$. Where $a \geq x \geq \mathrm{b}$ and $(\beta\colon v, w) = \int_0^1 u^{v-1}(1-u)^{w-1}du$. [Ref. 12]

The observed cost variances tended to assume one of two shapes. If the distribution was skewed to the left, with a majority of the observations clustering close to zero, then the distribution assumed a J shape, characteristic of the Beta distribution with (v-1)(w-1) < 0. If a relatively large number of observations occurred in the tail of the distribution then the distribution tended to assume a U shape where v < 1 and w < 1.

The estimated parameters provided by BestFit were used to obtain the percentile values. The percentile values were then converted to values ranging from $a \leq \mathrm{x} \leq b$ by arithmetic manipulation of the original formula.

The distributions shown in Section A, have a Beta distribution ranging from 0 to 1 superimposed over data ranging from a to b.

D. NON-PARAMETRIC TESTS OF THE HYPOTHESES

1. The Mann-Whitney Test

The Mann-Whitney Test tests for differences between the means of two populations. The test statistic is given by: U - μ_U/σ_U = Z. For a two tailed test the decision criterion is: Reject H_0 if $Z > -z_{a/2}$ or $Z < z_{a/2}$. For all four tests alpha is set at .05. Therefore, a/2 equals .025. The value of $z_{a/2}$ equals 1.96.

2. Hypothesis 2

$\mu_{fp} = \mu_c$. This hypothesis tests for differences in the means of fixed-price contracts and the mean of cost-type contracts. H_0, the null hypothesis, is the mean cost variance of fixed-price contracts equals the mean of cost-type contracts. H_A, the alternative hypothesis, is the means are not equal. This is a two tailed test. The purpose of this test is to determine if the choice of contract type contributed to the exceptional cost overruns in the A-12 program.

A requirement of the Mann-Whitney test is the populations must be the same, except for possible locations of the mean. The standard deviations of cost-type contracts and fixed-price type contracts was significantly different: 28.23 and 16.13 respectively. To standardize the two populations, each set of data was divided by its standard deviation before conducting the test. The test statistics for Hypothesis 2 are as follows:

From the results of the test the null hypothesis can not be rejected. There is no statistical difference in the means of the two populations. The test statistics for this test are given below:

R1	R2	n1	n2	Test Statistic
381	1104	15	39	0.6083

3. Hypothesis 3

$\mu_{acft} = \mu_{sample}$. Hypothesis 3 tests for differences in the cost variances of aircraft contracts and other programs. This test examines if aircraft programs experience statistically different cost variances than other type of programs. The mean cost variance of aircraft programs is -14.03 with standard deviation 15.69. The mean cost variance of other programs in the sample is -14.10 with standard deviation 16.43. No difference was assumed between the two populations. As would be expected, with similar means and standard deviations, the null hypothesis could not be rejected. The test statistics are given below:

R1	R2	n1	n2	Test Statistic
324	711	15	30	0.5056

4. Hypothesis 4

$\mu_{cbbfp} = \mu_{cbbc}$. Hypothesis 4 is similar to Hypothesis 2. Hypothesis 2 tested for differences in the cost variances between fixed-price type and cost-type contracts. Hypothesis 4 tests for differences in the mean budget adjustments. The mean CBB adjustment for fixed-price type contracts is 43.93 with standard deviation 59.84. The mean CBB adjustment for cost-type contracts is 57.24 with standard deviation 54.37.

The test statistics, for Hypothesis 4, are given below:

R1	R2	n1	n2	Test Statistic
115	320	8	21	0.244

The null hypothesis could not be rejected. There is no statistical difference between the mean CBB adjustments based on contract type.

5. Hypothesis 5.

$\mu_{cbbacft} = \mu_{cbbsample}$. Hypothesis 5 tests for differences in the CBB adjustments in aircraft programs versus other types of programs. The mean CBB adjustment for aircraft programs is 94.15 with standard deviation 86.15. The mean CBB adjustment for other types of programs in the sample is 42.99 with standard deviation 40.20. The test statistics are given below:

R1	R2	n1	n2	Test Statistic
80	355	6	23	0.5384

The two populations were divided by their respective standard deviations before the test to eliminate the difference in variance between the two populations. The test results indicate that the null hypothesis can not be rejected. Despite the apparent differences in the means of the two populations, there is insufficient evidence to claim that aircraft programs mean budget adjustments are greater than other programs.

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